US009341278B2

(12) United States Patent
Esche

(10) Patent No.: US 9,341,278 B2
(45) Date of Patent: May 17, 2016

(54) **SYSTEM AND METHOD FOR MANUALLY OVERRIDING A SOLENOID VALVE OF A FAUCET**

(71) Applicant: **Kohler Co.**, Kohler, WI (US)

(72) Inventor: **John C. Esche**, Kohler, WI (US)

(73) Assignee: **KOHLER CO.**, Kohler, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 288 days.

(21) Appl. No.: **13/794,614**

(22) Filed: **Mar. 11, 2013**

(65) **Prior Publication Data**

US 2014/0054478 A1 Feb. 27, 2014

Related U.S. Application Data

(60) Provisional application No. 61/692,966, filed on Aug. 24, 2012, provisional application No. 61/692,912, filed on Aug. 24, 2012, provisional application No. 61/692,959, filed on Aug. 24, 2012.

(51) **Int. Cl.**

F16K 31/06	(2006.01)
F16K 31/50	(2006.01)
F16K 31/05	(2006.01)
F16K 31/40	(2006.01)

(52) **U.S. Cl.**

CPC ***F16K 31/05*** (2013.01); ***F16K 31/06*** (2013.01); ***F16K 31/40*** (2013.01)

(58) **Field of Classification Search**

CPC F16K 31/05; F16K 31/06
USPC 251/129.03, 274, 339
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,036,808 A *	5/1962	Fox	251/54
3,491,381 A	1/1970	Cathcart	
3,576,277 A	4/1971	Blackman	
4,052,035 A	10/1977	Kenny et al.	
4,092,085 A	5/1978	McMaster-Christie	
4,521,759 A *	6/1985	Gibas	335/255
4,679,017 A *	7/1987	Mishler et al.	335/164
4,735,357 A	4/1988	Gregory et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

CN	2081024 U	7/1991
CN	2641155 Y	9/2004

(Continued)

OTHER PUBLICATIONS

Brizo Pascal, Obedient-Intelligent, brochure, 2007, 3 pages.

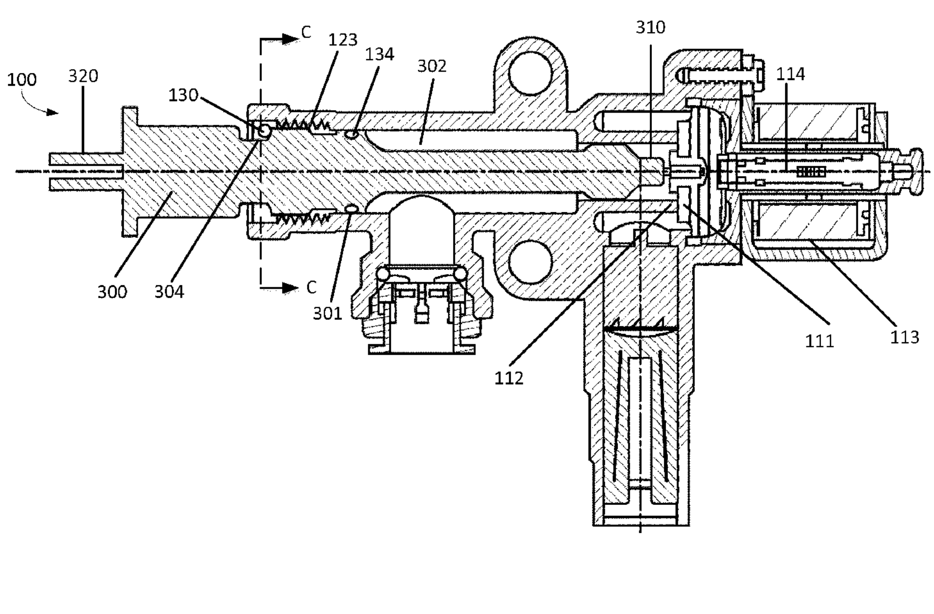
(Continued)

Primary Examiner — Marina Tietjen
Assistant Examiner — Seth W Mackay-Smith
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

A system for manually overriding a solenoid operated valve in an event of power failure is provided. The system includes a solenoid operated valve and a lifter. The solenoid operated valve includes a valve body including a sealing surface, a fluid inlet and a fluid outlet, a sealing element selectively separating the fluid inlet from the fluid outlet and a solenoid configured to selectively couple and decouple the sealing element to the sealing surface. The lifter is threadedly coupled to the solenoid operated valve. Rotation of the lifter relative to the valve body in a first direction causes the lifter to decouple the sealing element from the sealing surface.

17 Claims, 31 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,767,922	A	8/1988	Stauffer	
4,886,207	A	12/1989	Lee et al.	
4,915,347	A	4/1990	Iqbal et al.	
5,025,516	A	6/1991	Wilson	
5,074,520	A	12/1991	Lee et al.	
5,095,941	A	3/1992	Betz	
5,224,509	A	7/1993	Tanaka et al.	
5,243,717	A	9/1993	Yasuo	
5,287,570	A	2/1994	Peterson et al.	
5,297,774	A	3/1994	Chuang	
5,595,216	A	1/1997	Pilolla	
5,755,262	A	5/1998	Pilolla	
5,758,688	A	6/1998	Hamanaka et al.	
6,003,170	A	12/1999	Humpert et al.	
6,067,673	A	5/2000	Paese et al.	
6,109,288	A	8/2000	Al-Hamlan	
6,202,980	B1	3/2001	Vincent et al.	
6,250,601	B1	6/2001	Kolar et al.	
6,310,530	B1 *	10/2001	Jacobus	335/238
6,340,032	B1	1/2002	Zosimadis	
6,341,389	B2	1/2002	Philipps-Liebich et al.	
6,363,549	B2	4/2002	Humpert et al.	
RE37,888	E	10/2002	Cretu-Petra	
6,612,540	B2	9/2003	Bush	
D487,798	S	3/2004	Bayer	
6,874,535	B2	4/2005	Parsons et al.	
7,000,637	B1	2/2006	Kjaer	
7,028,725	B2	4/2006	Hooker	
7,114,510	B2	10/2006	Peters et al.	
7,150,293	B2	12/2006	Jonte	
7,464,418	B2	12/2008	Seggio et al.	
7,472,433	B2	1/2009	Rodenbeck et al.	
7,533,697	B2 *	5/2009	Zeiner et al.	137/899.2
7,537,023	B2	5/2009	Marty et al.	
7,624,757	B2 *	12/2009	Schmitt	137/606
7,627,909	B2	12/2009	Esche	
7,743,438	B2	6/2010	Chen	
7,921,480	B2	4/2011	Parsons et al.	
8,104,113	B2	1/2012	Rodenbeck et al.	
8,118,240	B2	2/2012	Rodenbeck et al.	
2005/0253103	A1	11/2005	Bente et al.	
2006/0202142	A1	9/2006	Marty et al.	
2007/0246550	A1	10/2007	Rodenbeck et al.	
2008/0072965	A1	3/2008	Buechel et al.	
2008/0093572	A1	4/2008	Wu	
2009/0078896	A1 *	3/2009	Clauss et al.	251/129.03
2009/0119832	A1	5/2009	Conroy	
2011/0001069	A1 *	1/2011	Zhang	251/129.01
2011/0139282	A1	6/2011	Loeck et al.	
2011/0185493	A1	8/2011	Chen	
2011/0186161	A1	8/2011	Chen	
2011/0210276	A1	9/2011	Chen	
2013/0248033	A1	9/2013	Parikh et al.	
2013/0248620	A1	9/2013	Evans et al.	
2013/0291978	A1	11/2013	Baker et al.	

FOREIGN PATENT DOCUMENTS

CN	2641405 Y	9/2004
DE	19712 222	10/1997

OTHER PUBLICATIONS

Moen Introduces MotionSense: A Uniquely Responsive, User-Friendly, Hands-Free Kitchen Faucet Experience, Apr. 2012, 3 pages.

MotionSense, http://www.moen.com/about-moen/smart-innovations/motionsense, Apr. 2012, 2 pages.

International Search Report for Application No. PCT/US2010/058730, mail date Jul. 3, 2011, 2 pages.

* cited by examiner

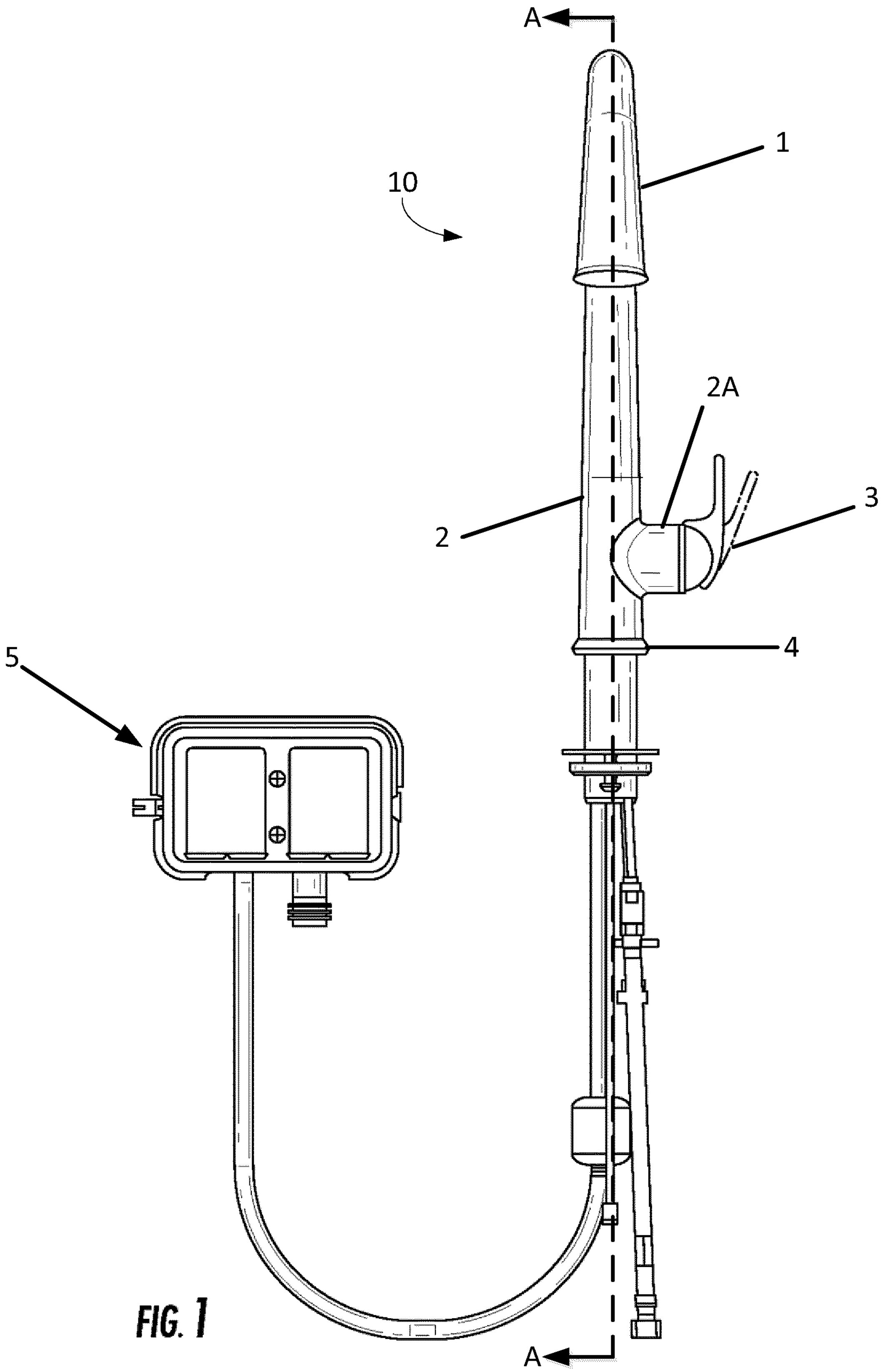


FIG. 1

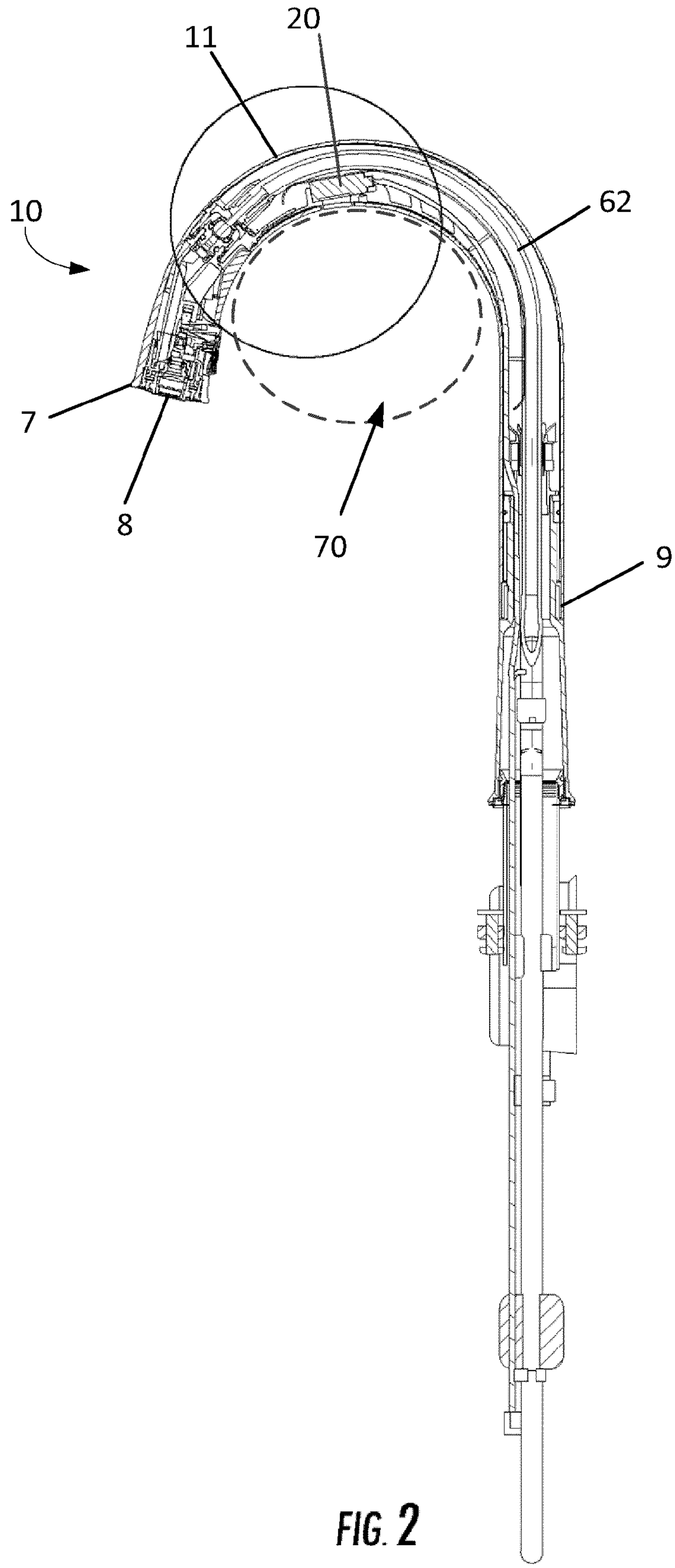


FIG. 2

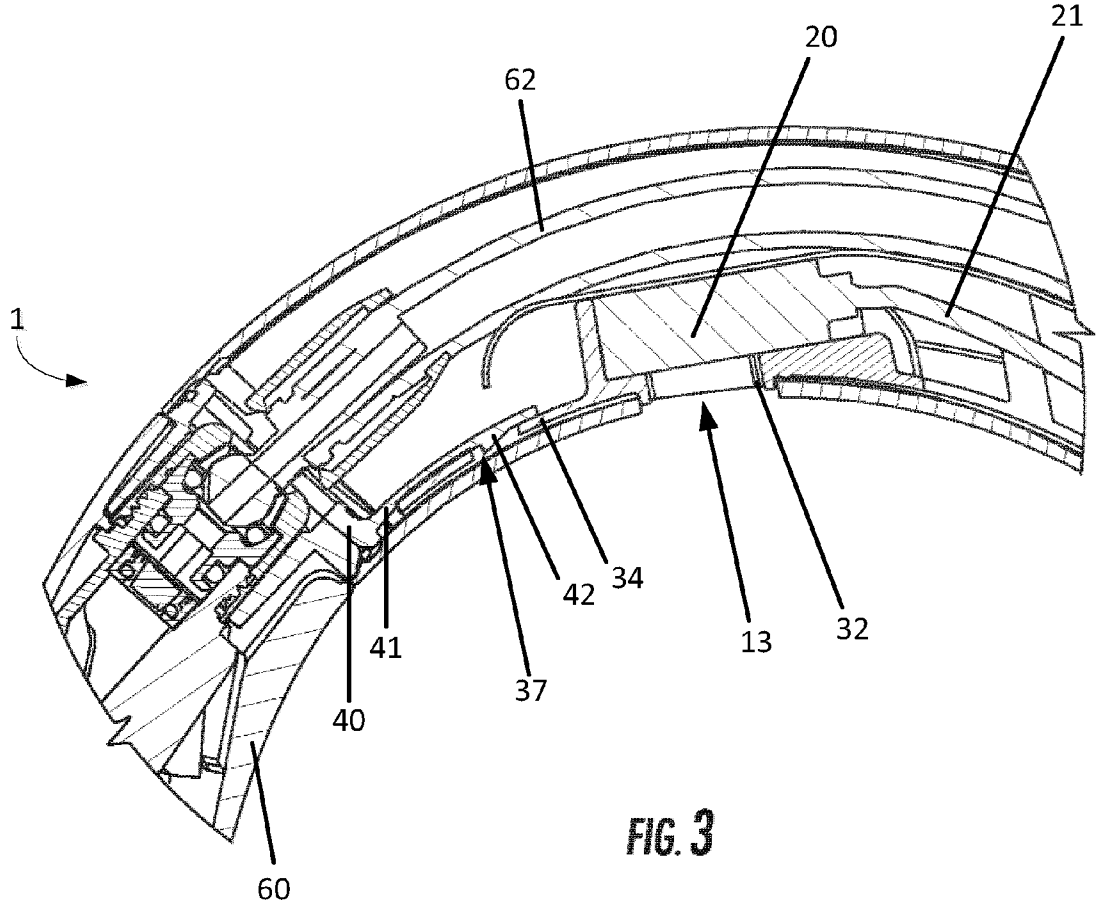


FIG. 3

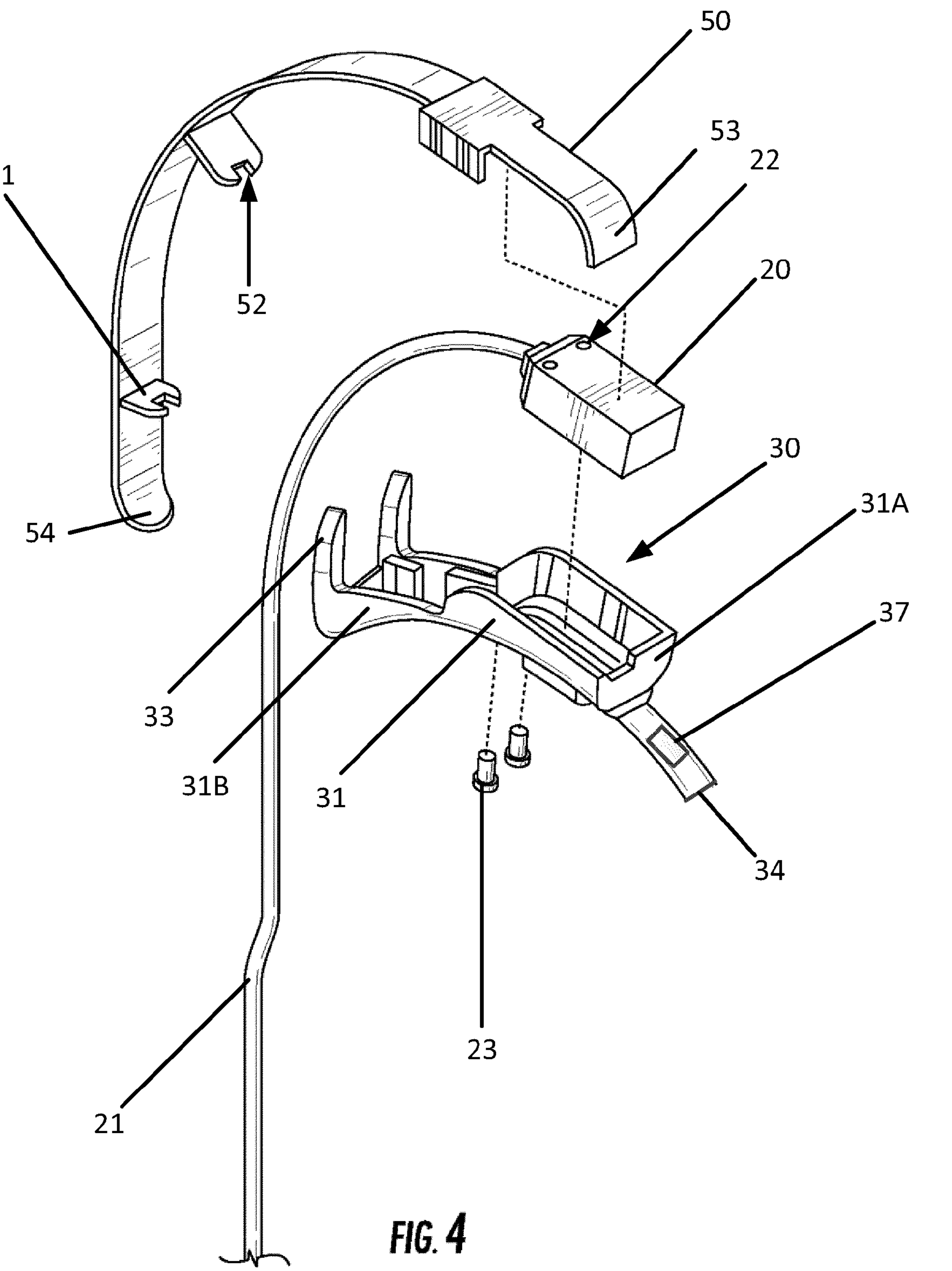


FIG. 4

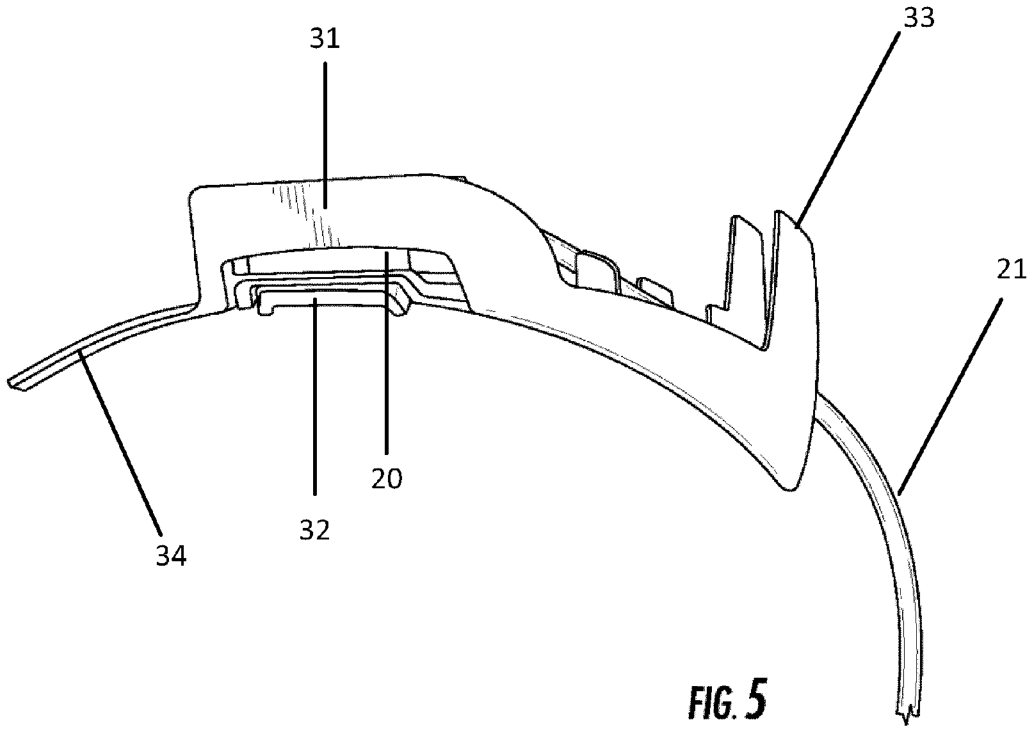


FIG. 5

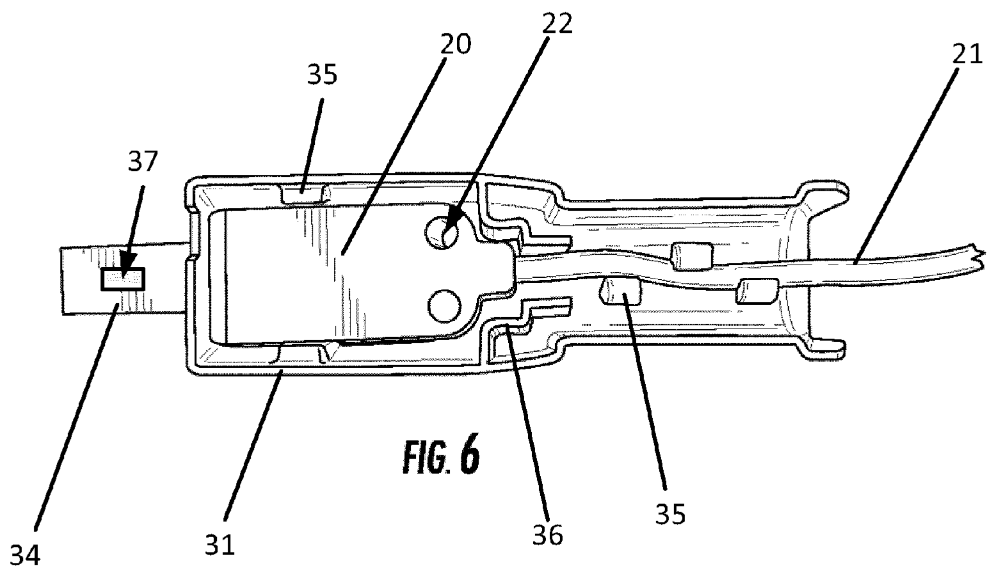


FIG. 6

Fig. 7

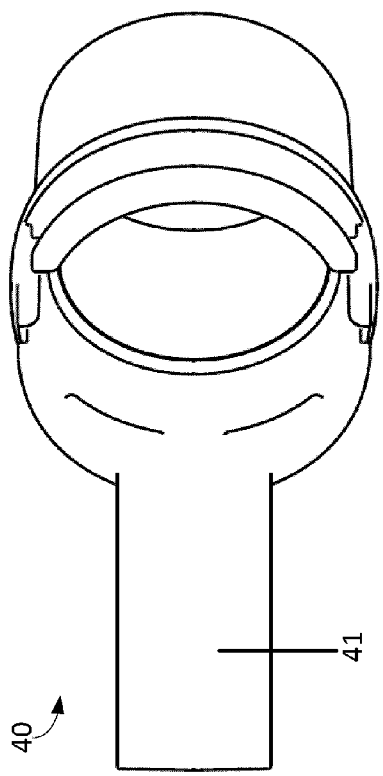
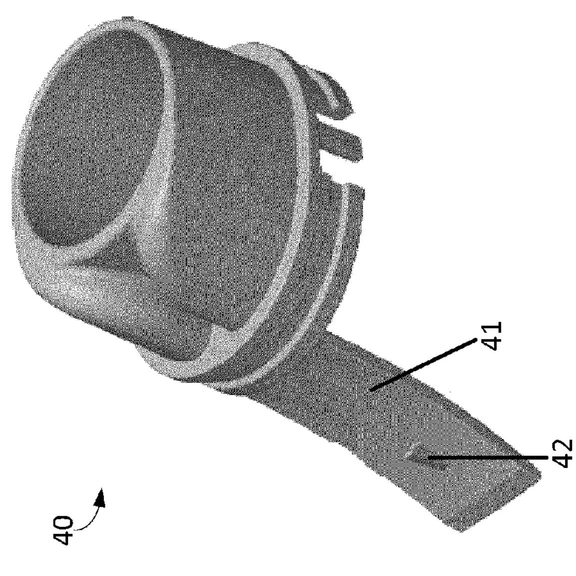


Fig. 8



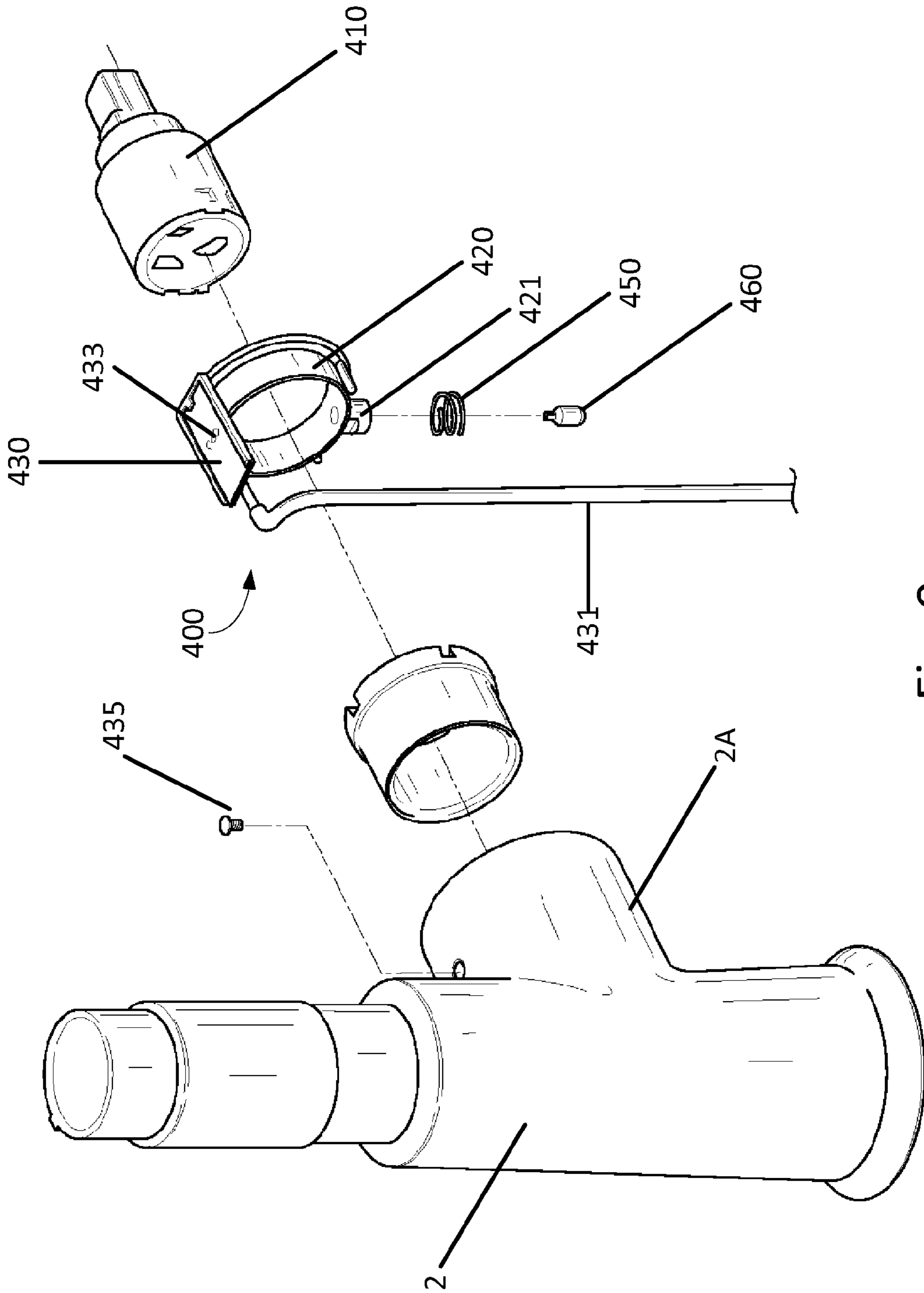


Fig. 9

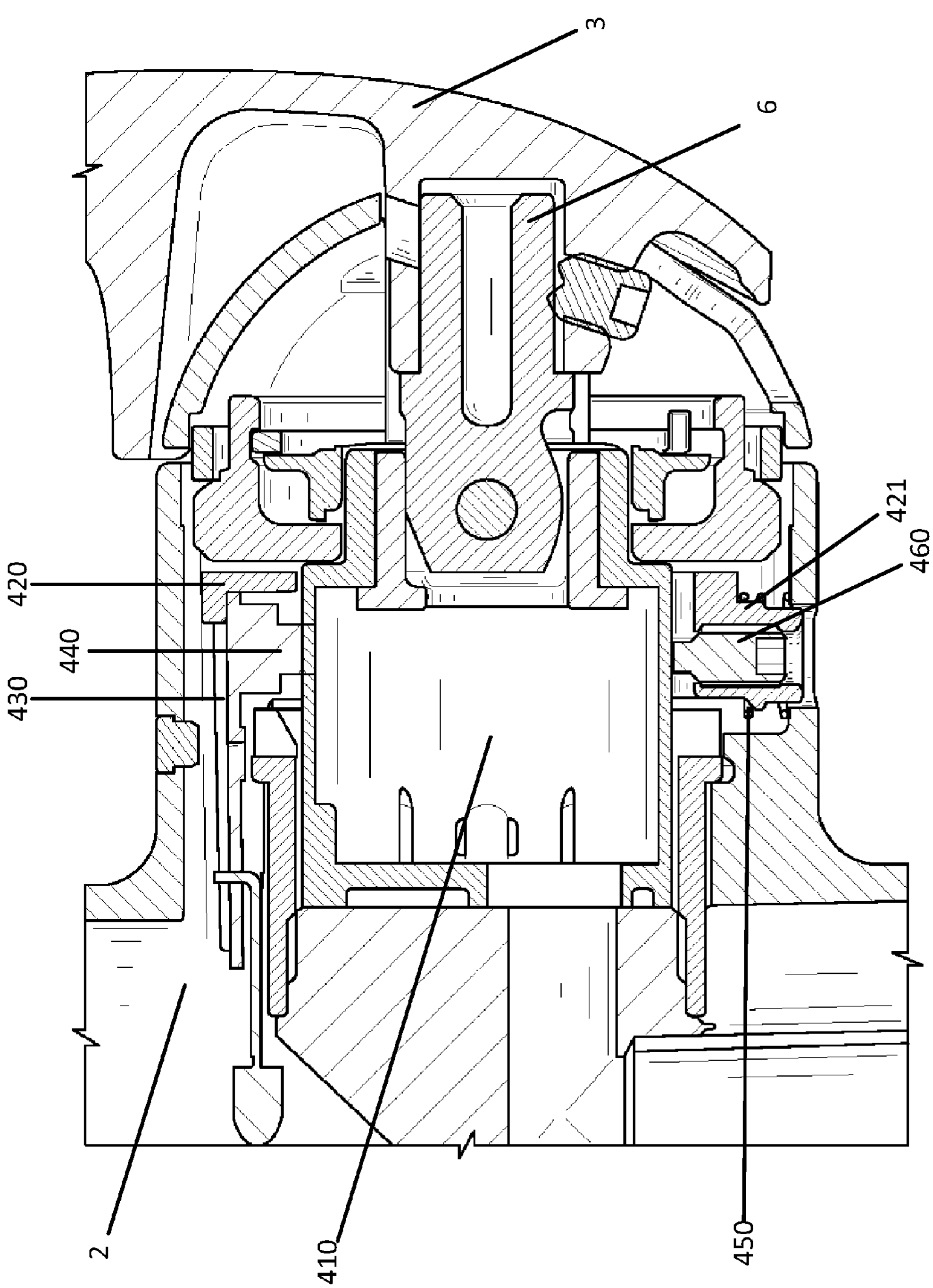


Fig. 10

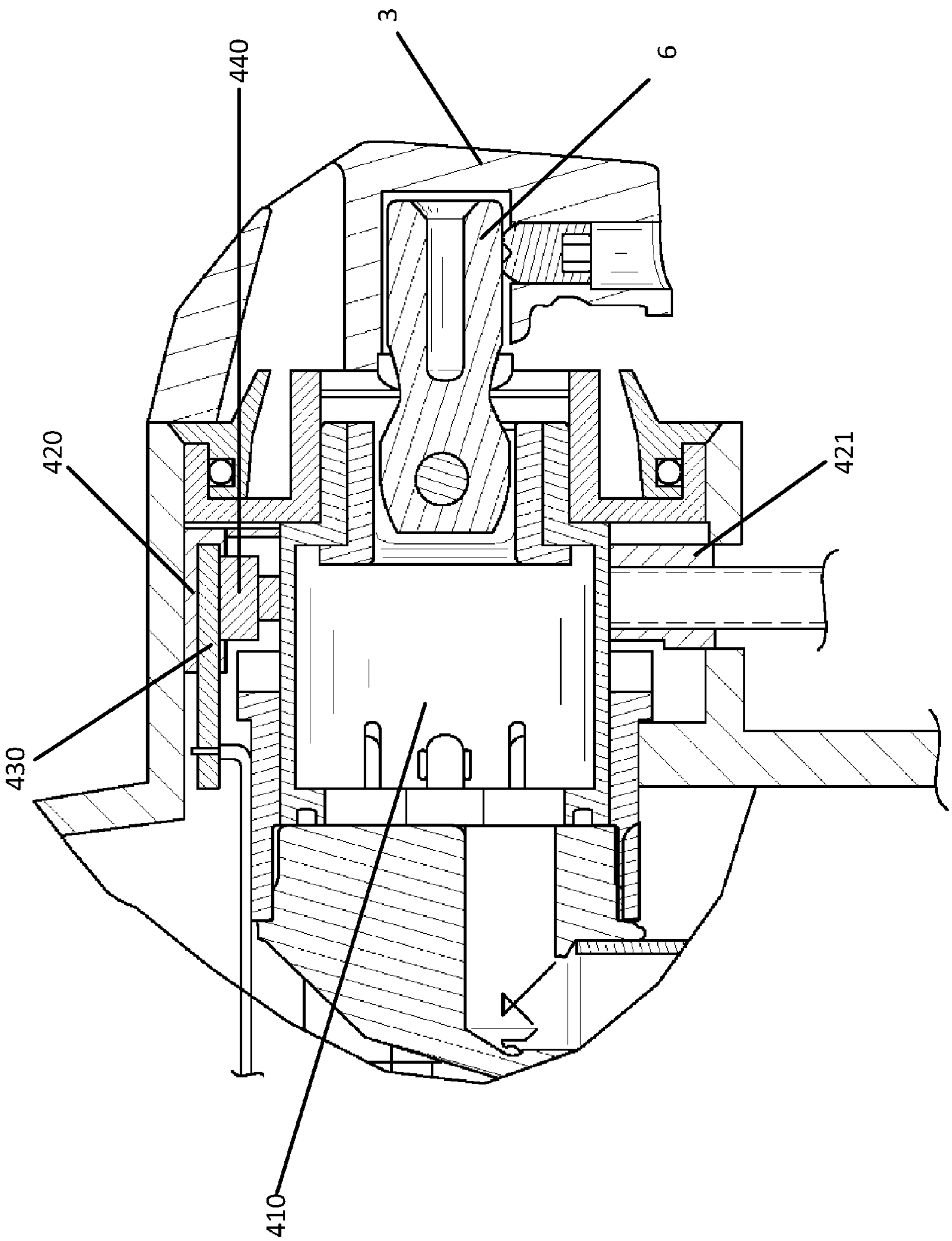


Fig. 11

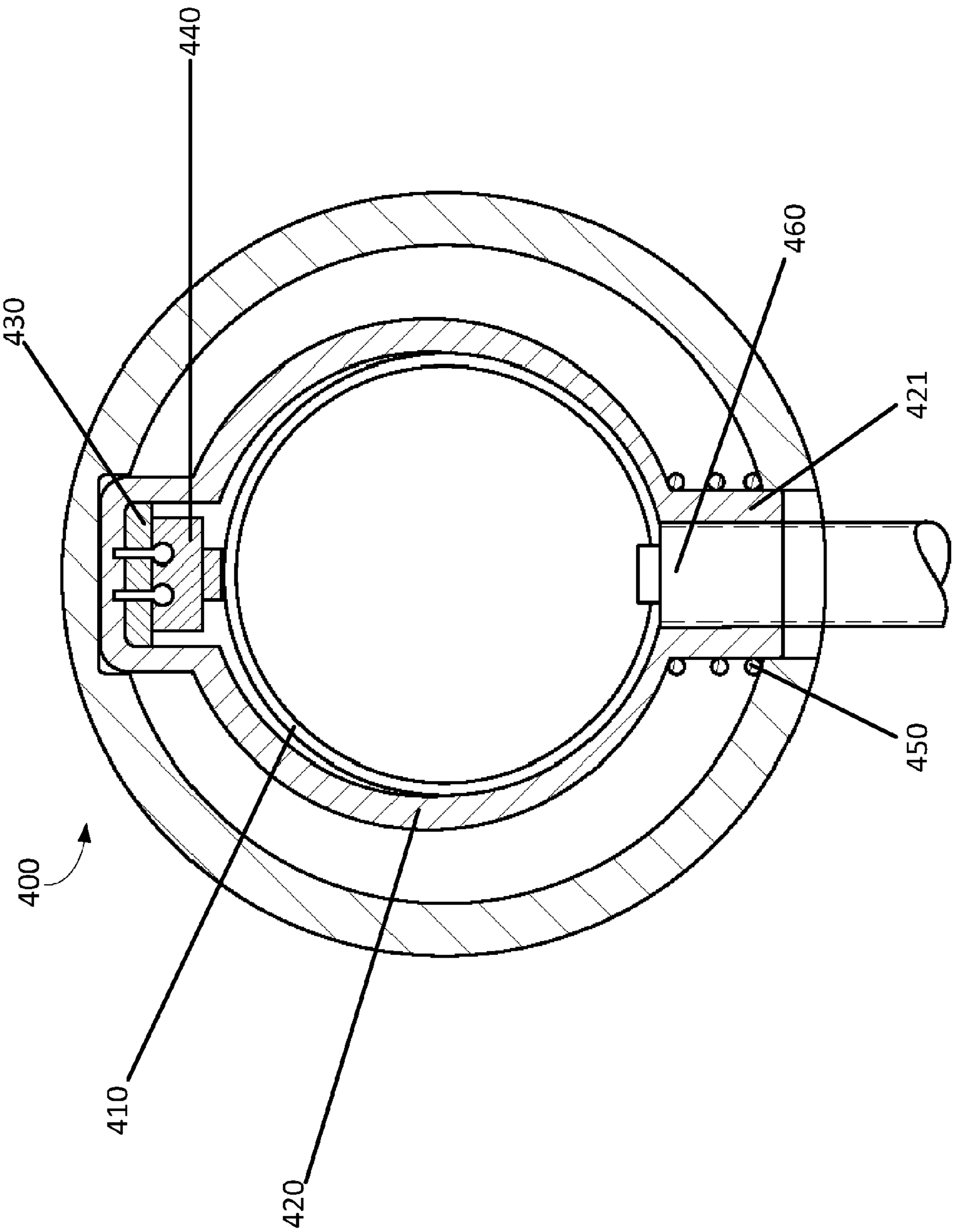


Fig. 12

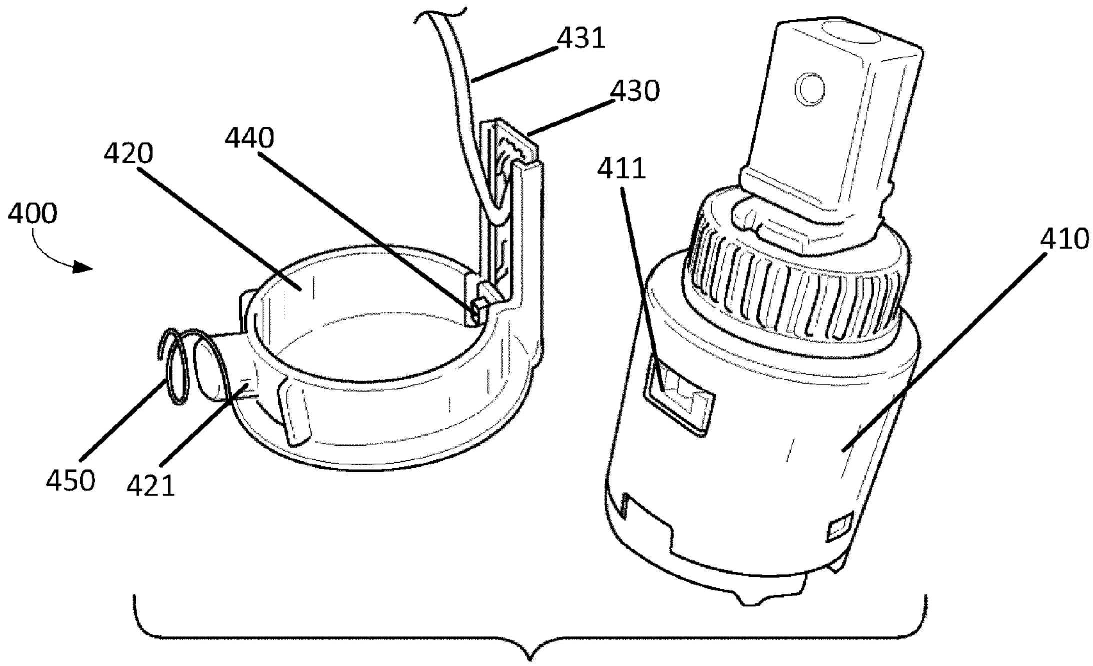

431
430
420
440
411
410
400
450
421

Fig. 13

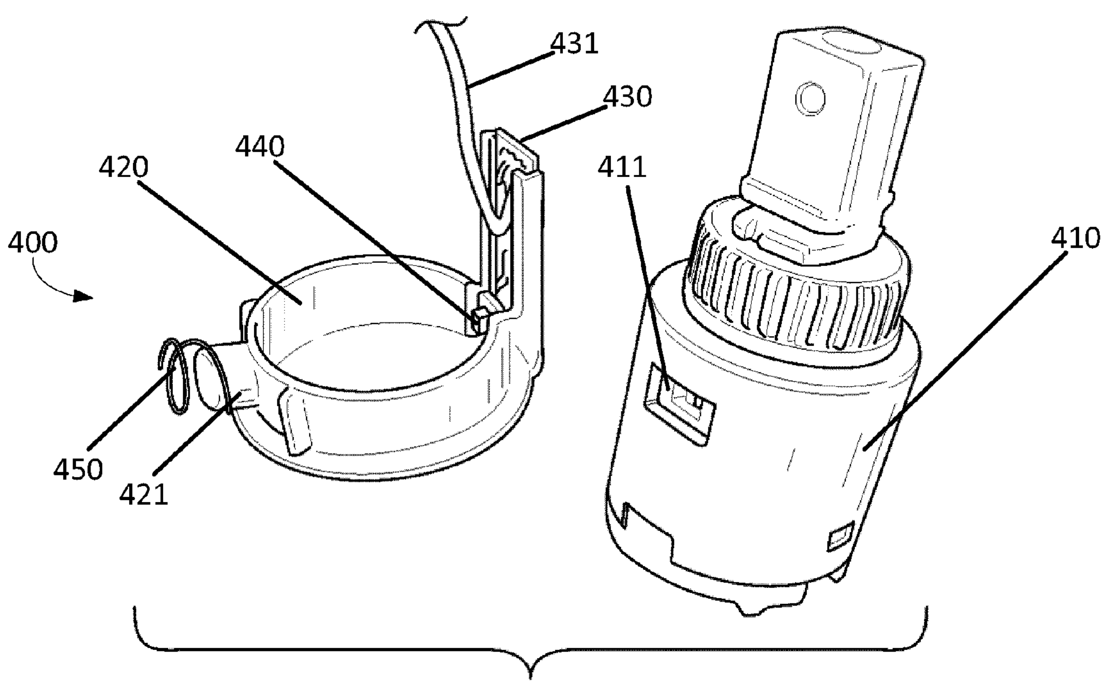

431
430
440
420
411
410
400
450
421

Fig. 14

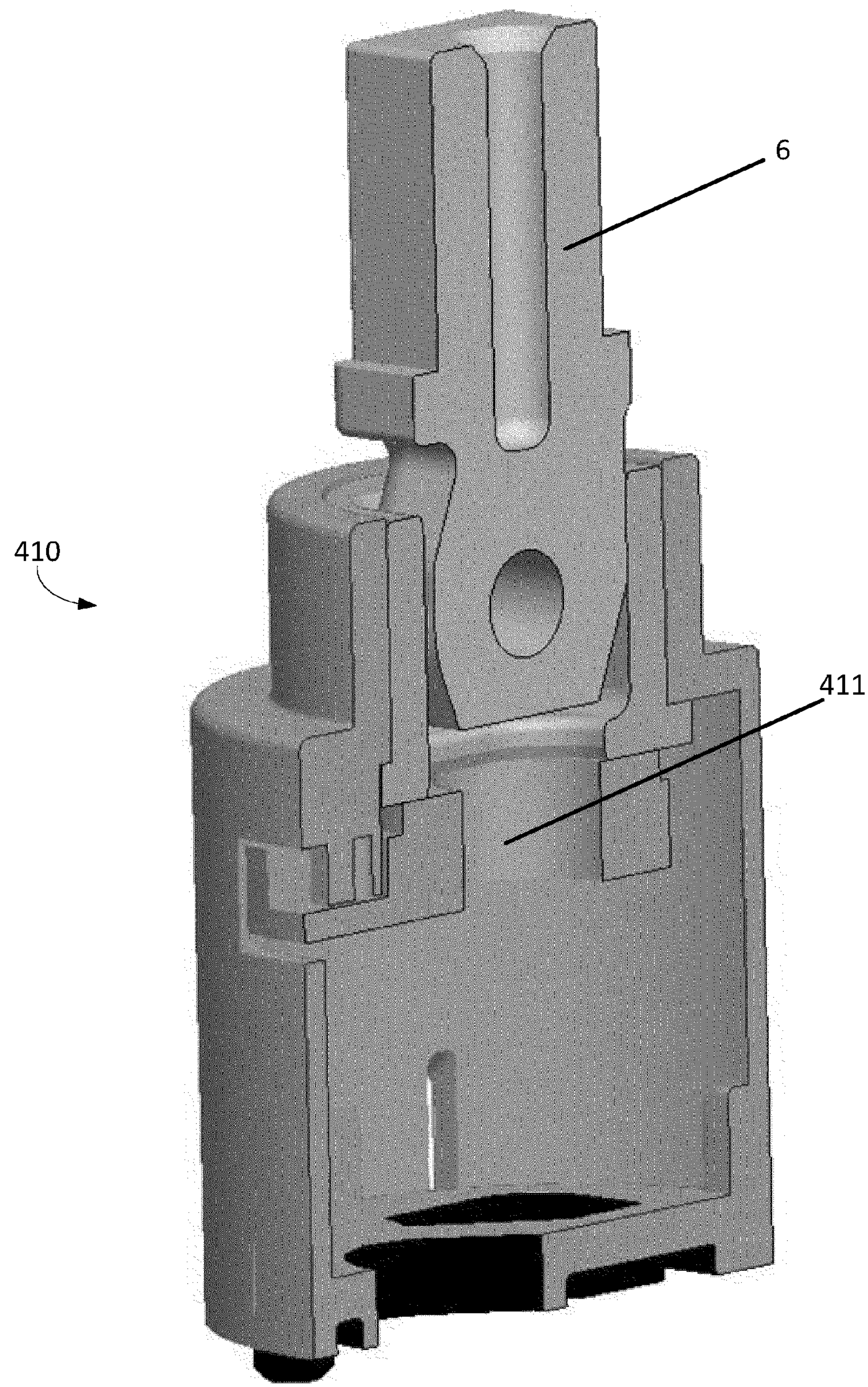


Fig. 15

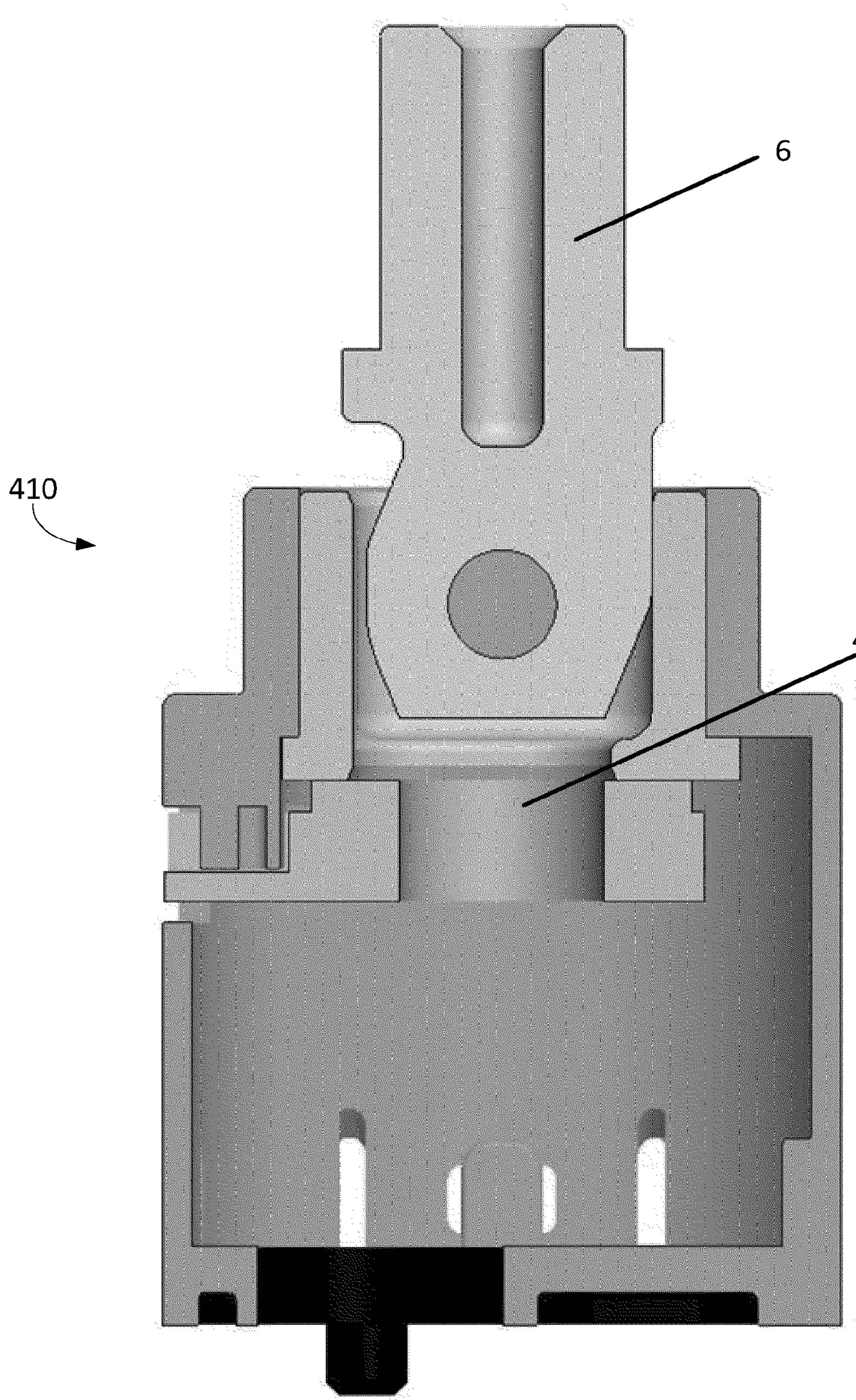


Fig. 16

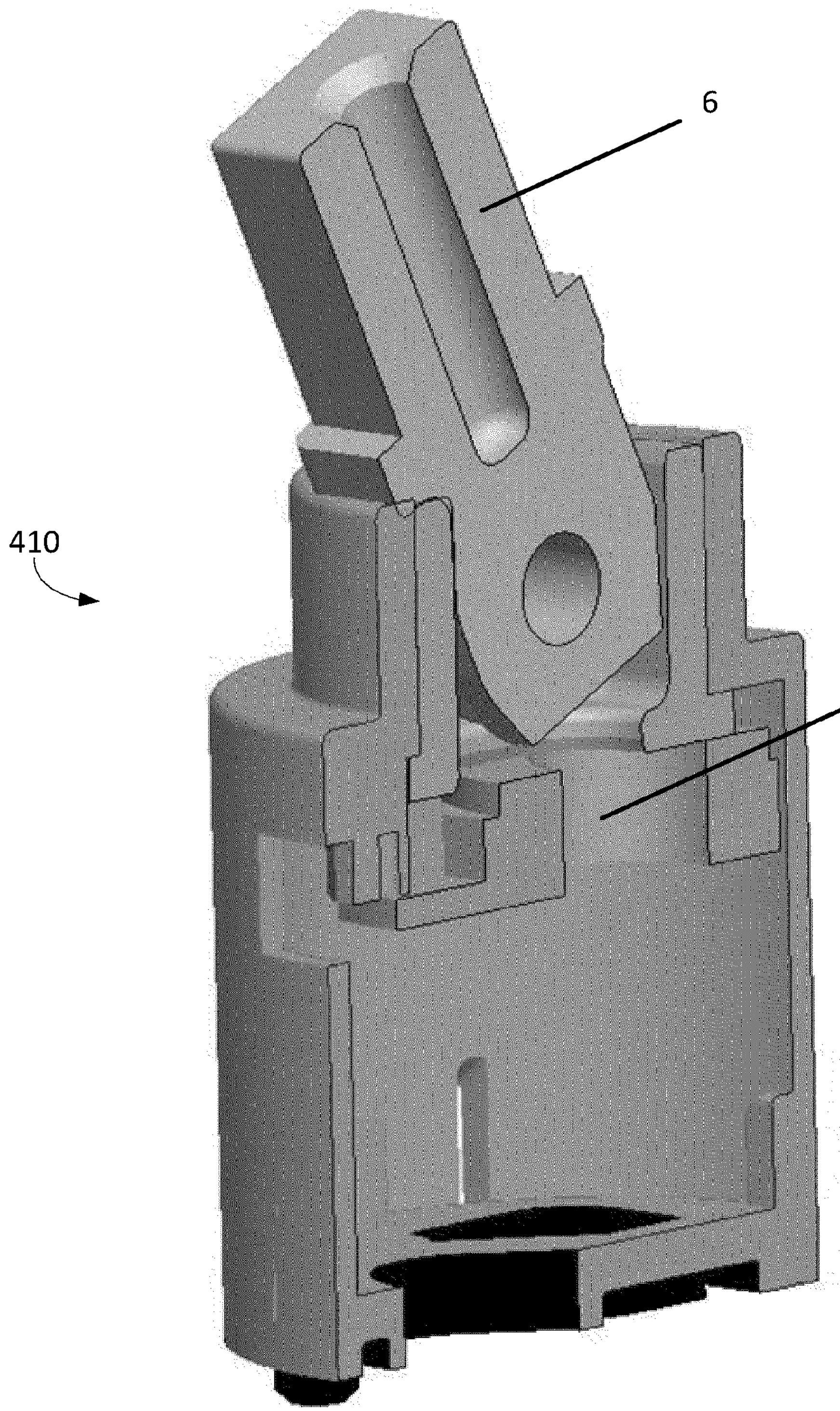


Fig. 17

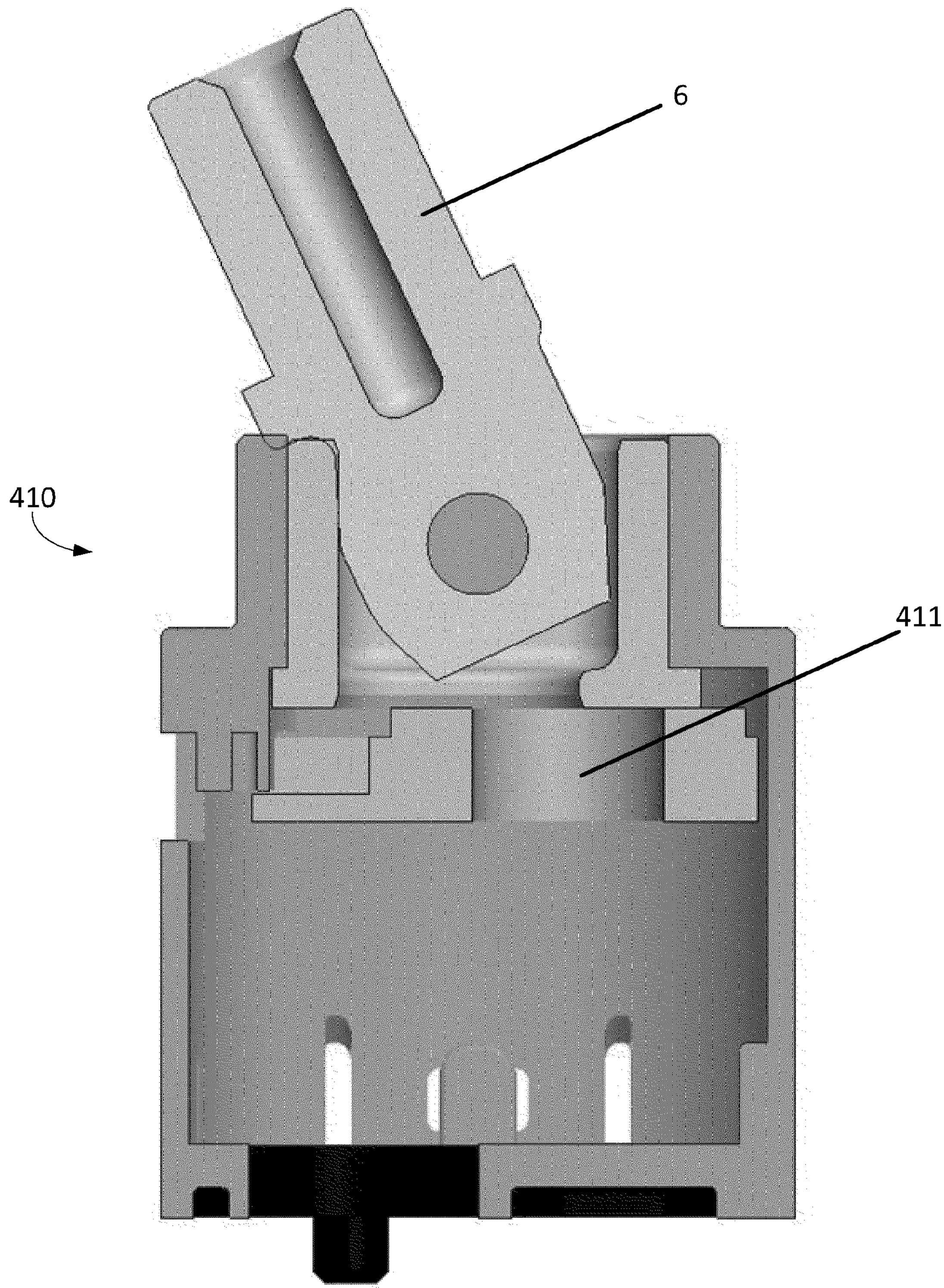


Fig. 18

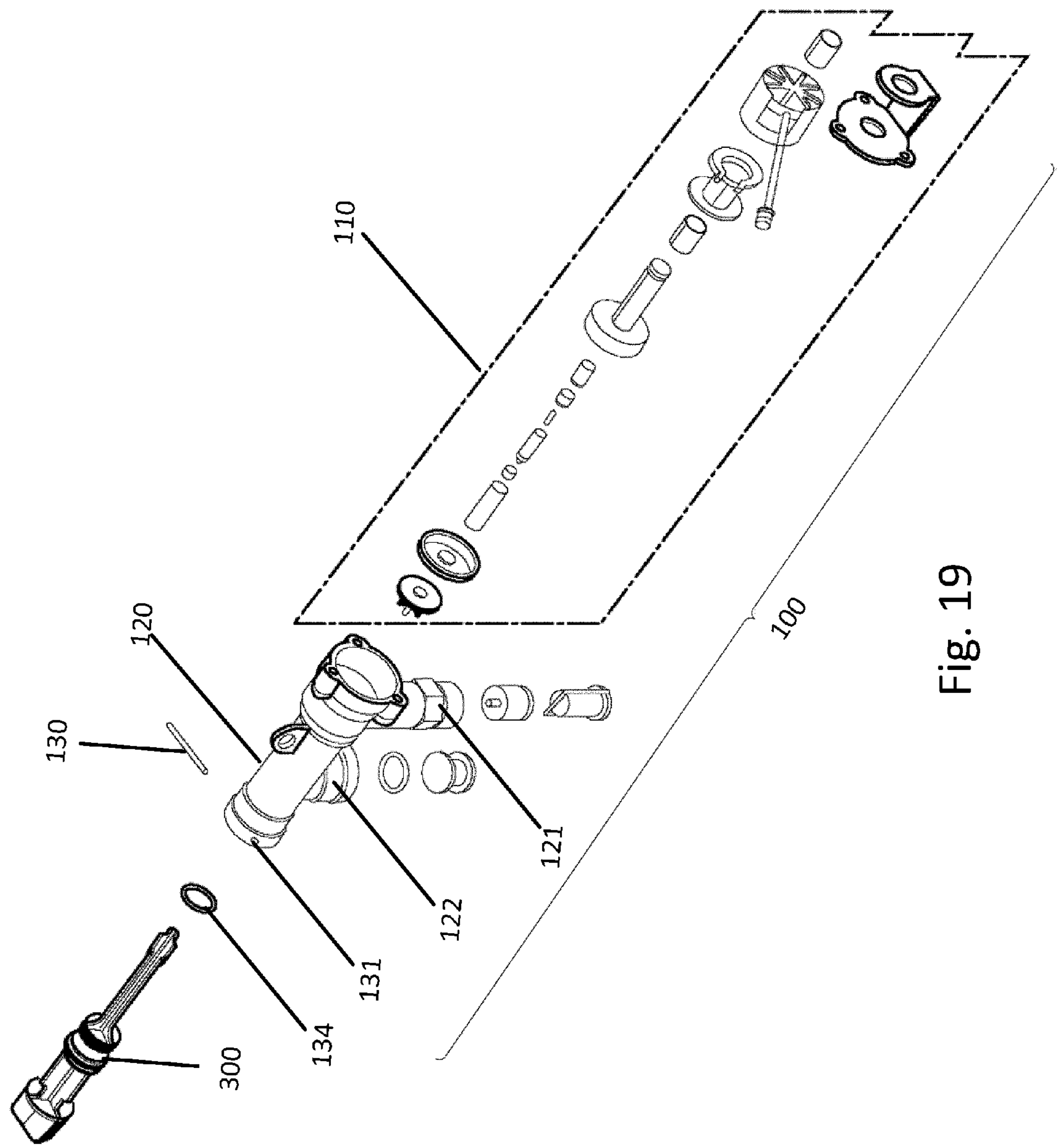


Fig. 19

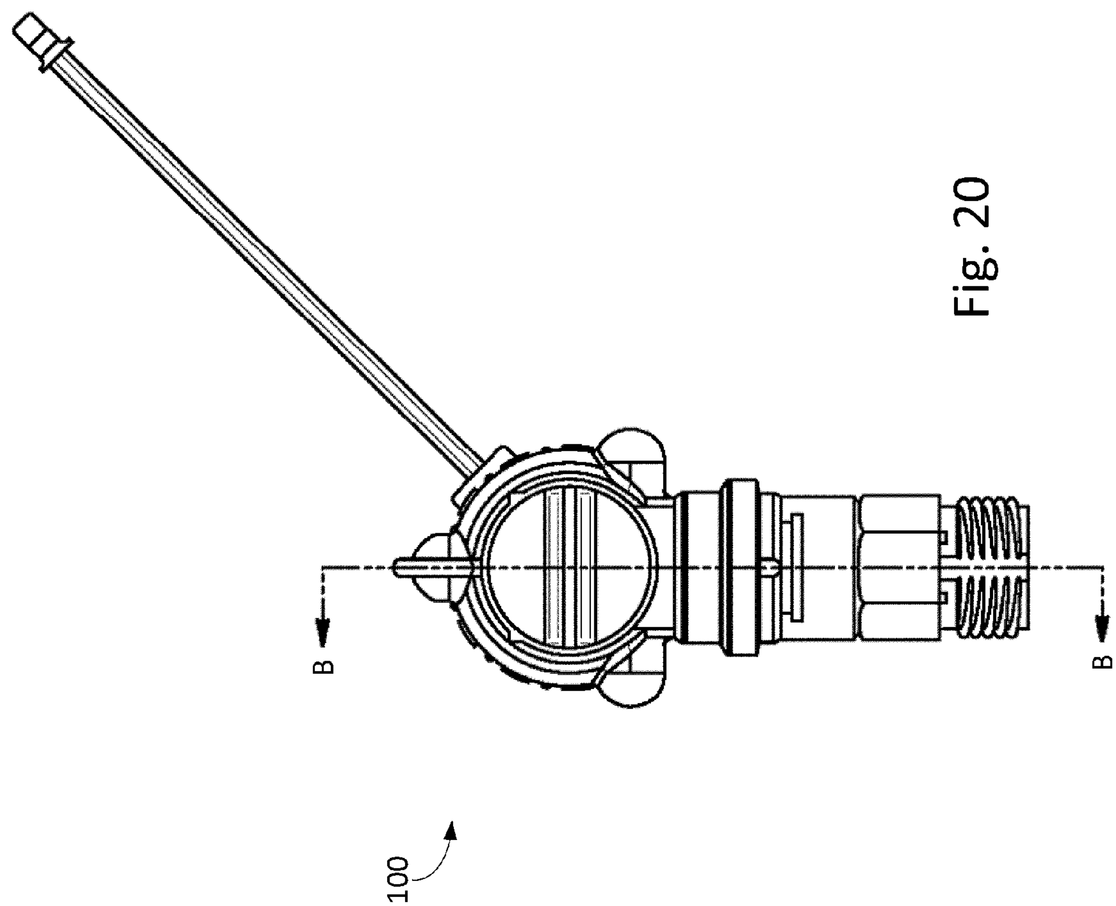


Fig. 20

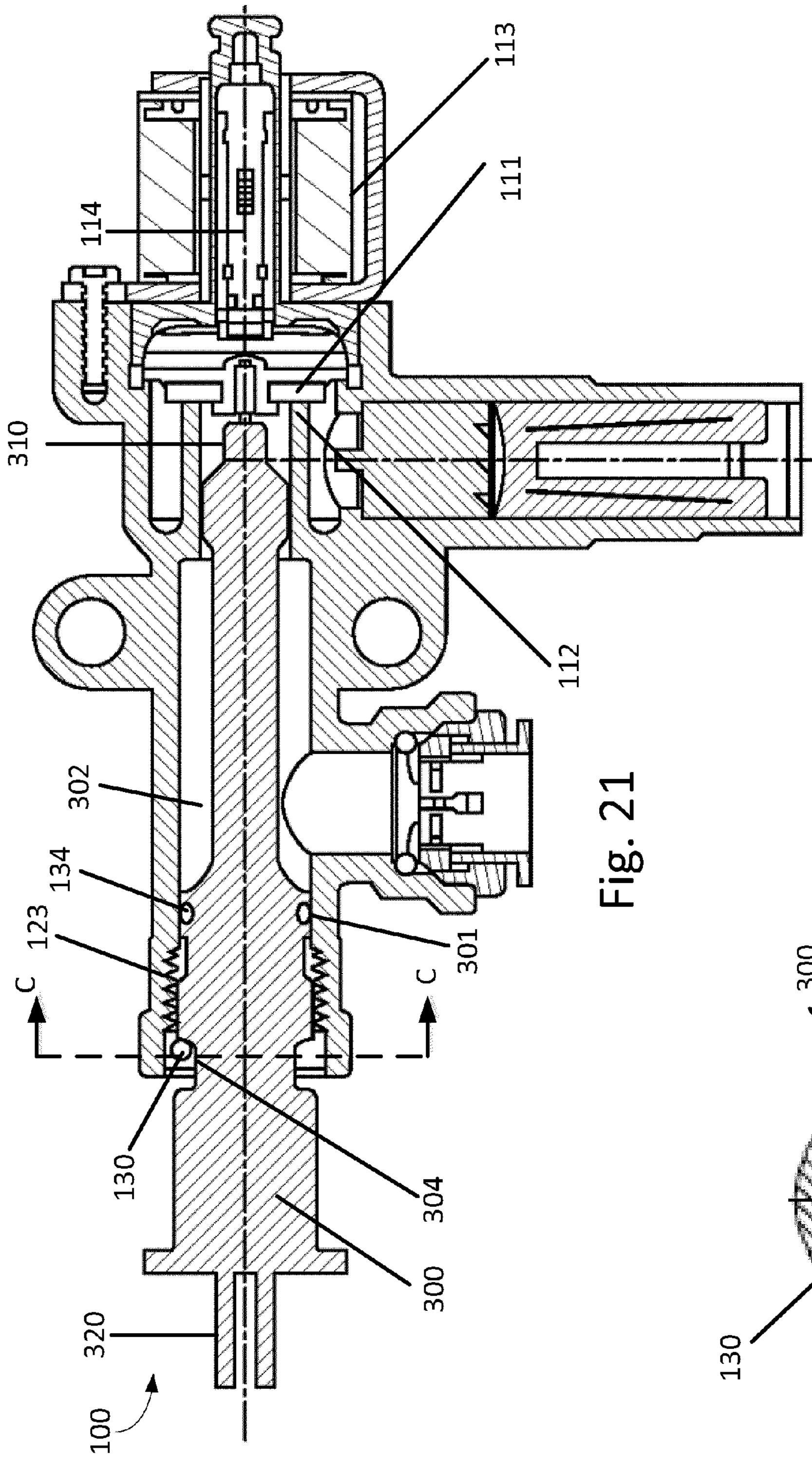

113
111
114
310
112
302
134
123
C
C
301
130
304
300
320
100

Fig. 21

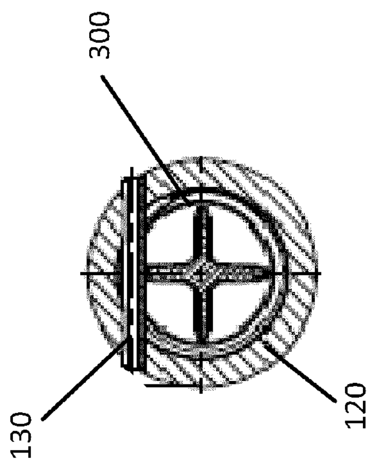

300
130
120

Fig. 22

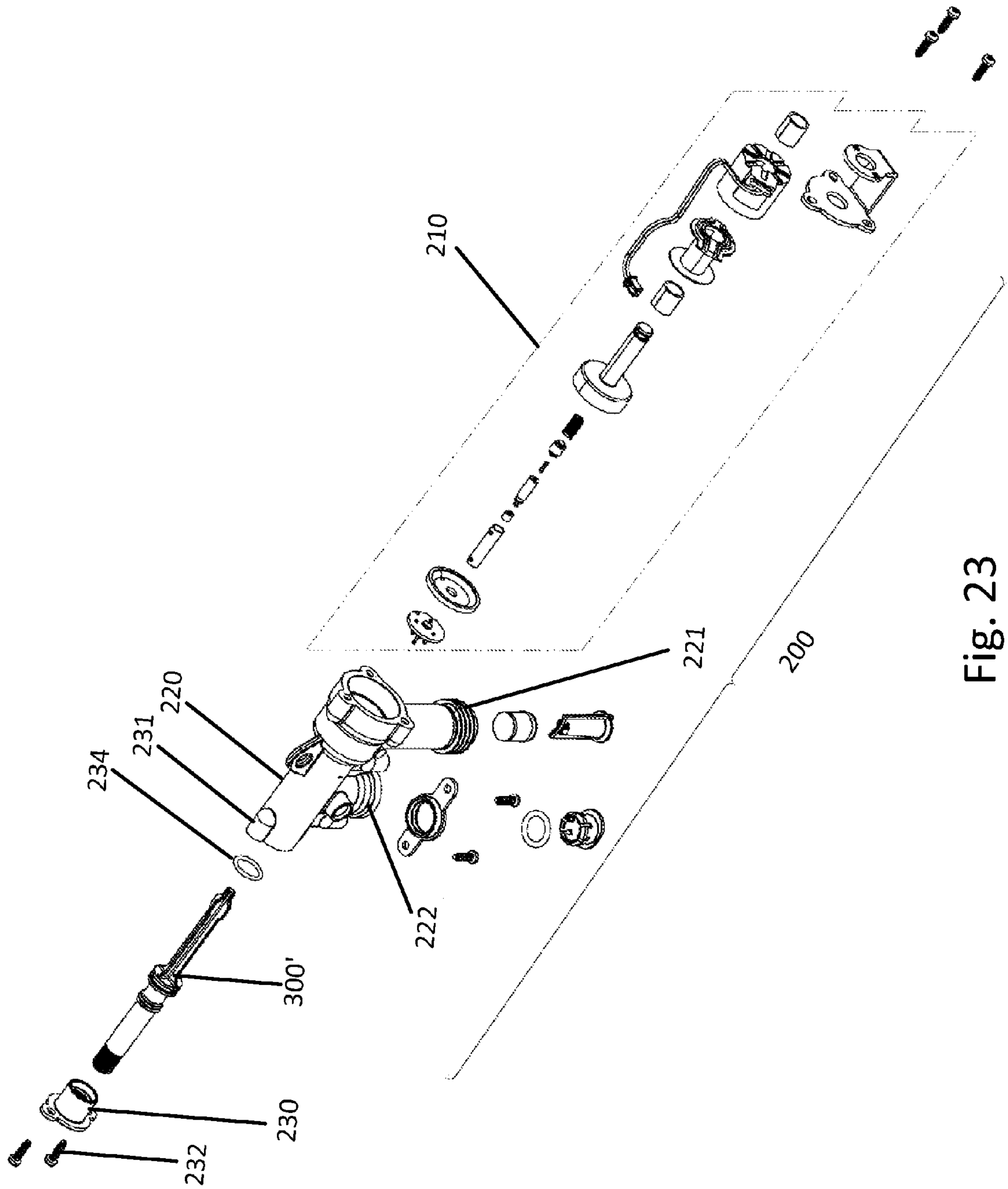


Fig. 23

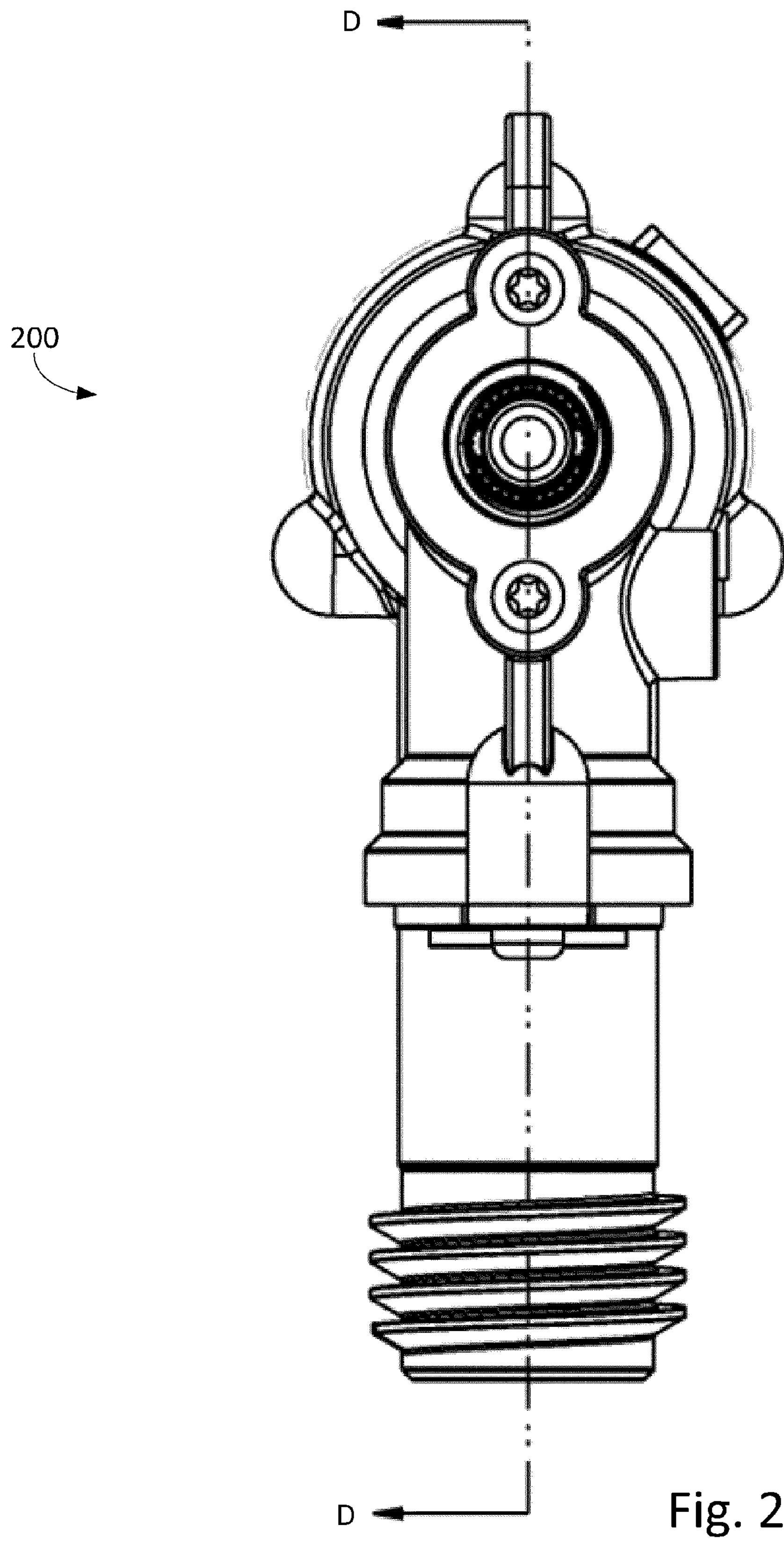


Fig. 24

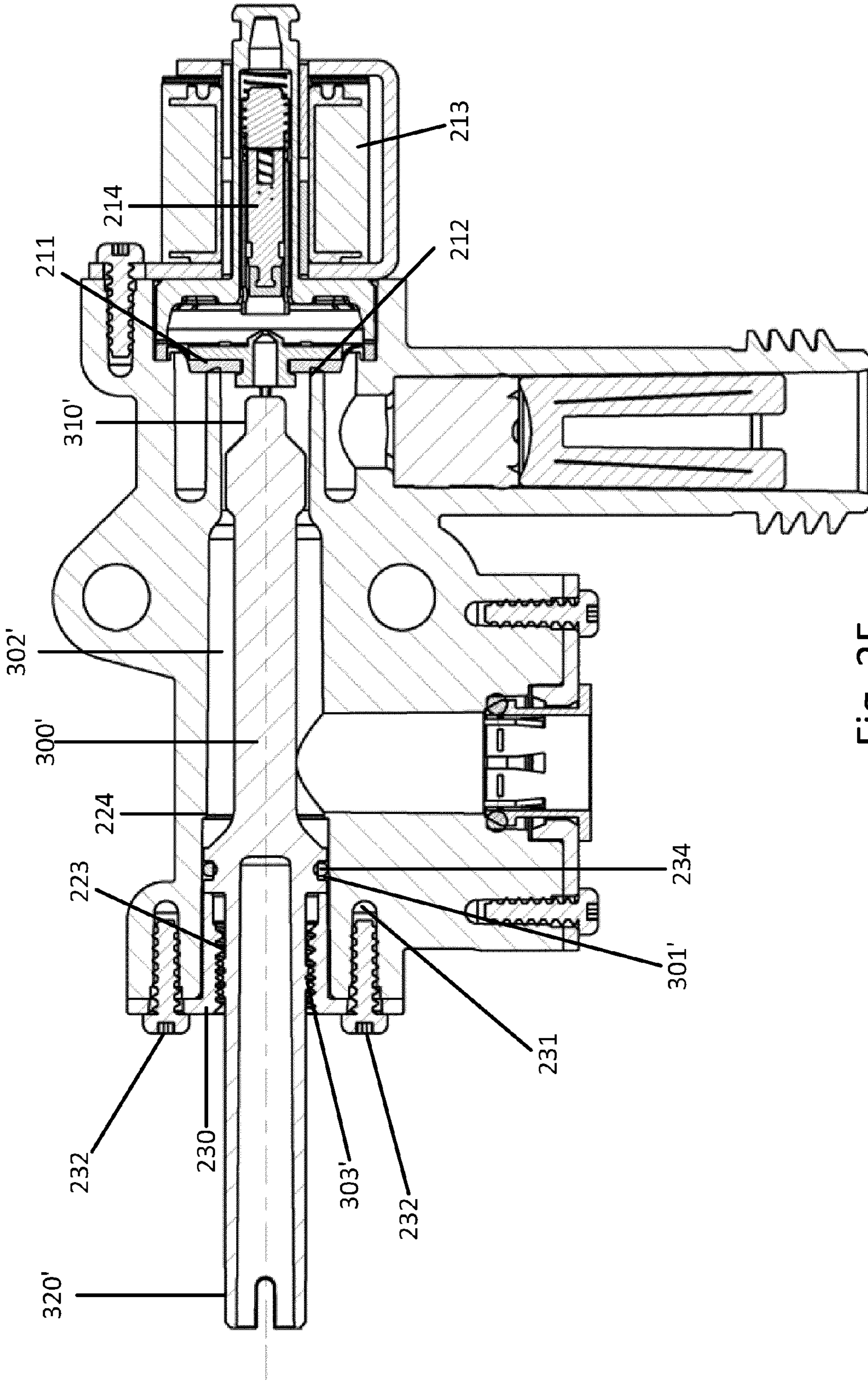

213
214
211
212
310'
302'
300'
224
223
234
301'
231
232
230
303'
232
320'

Fig. 25

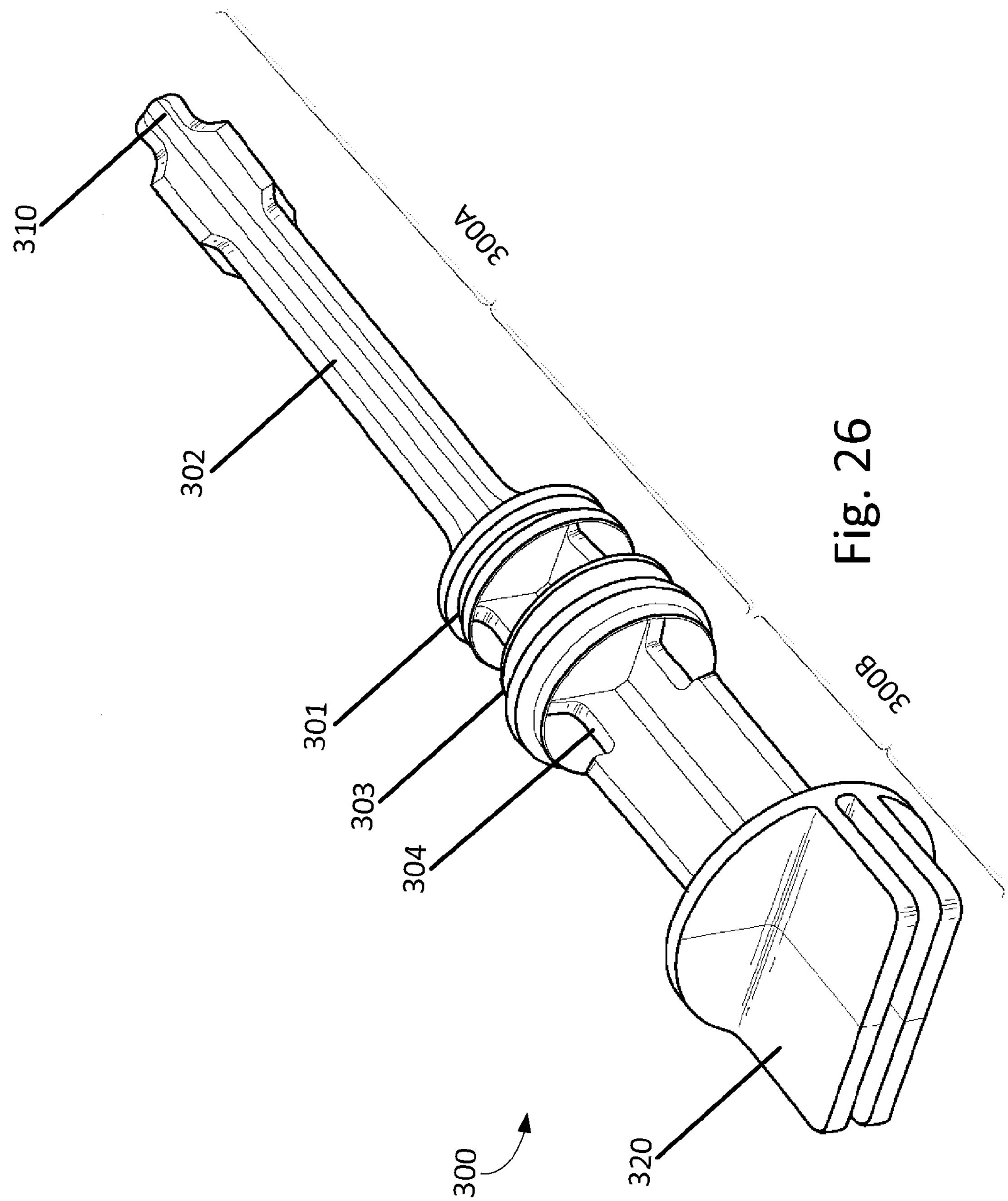


Fig. 26

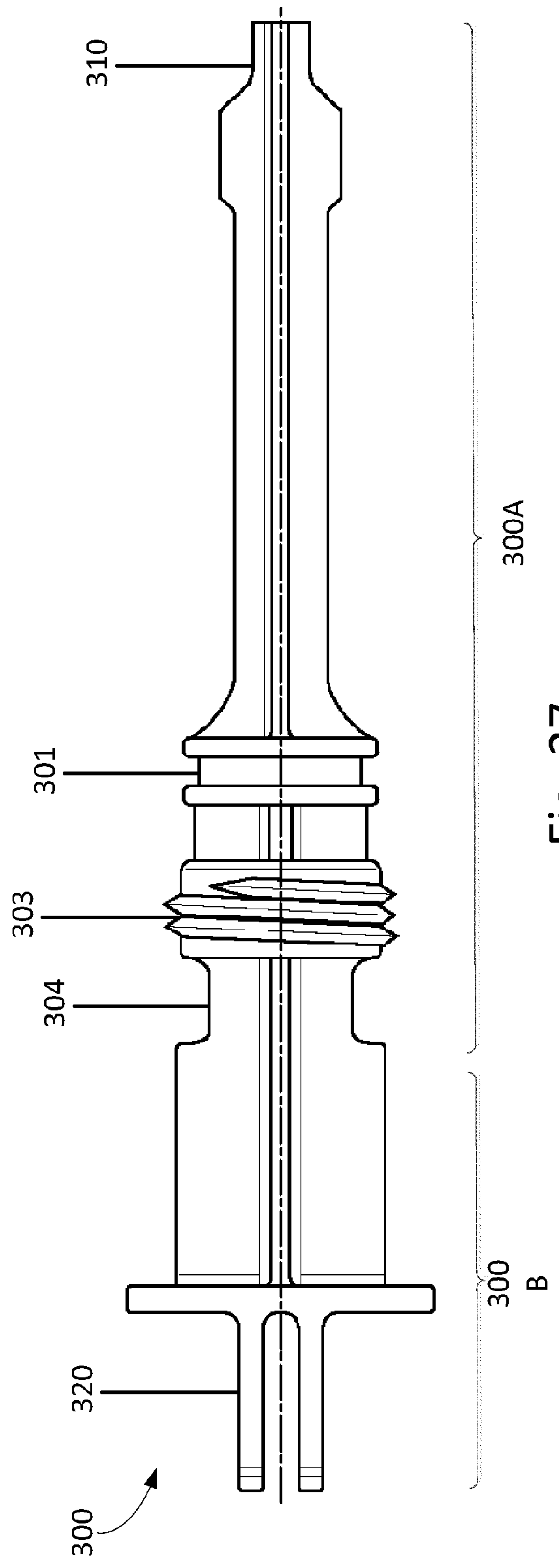


Fig. 27

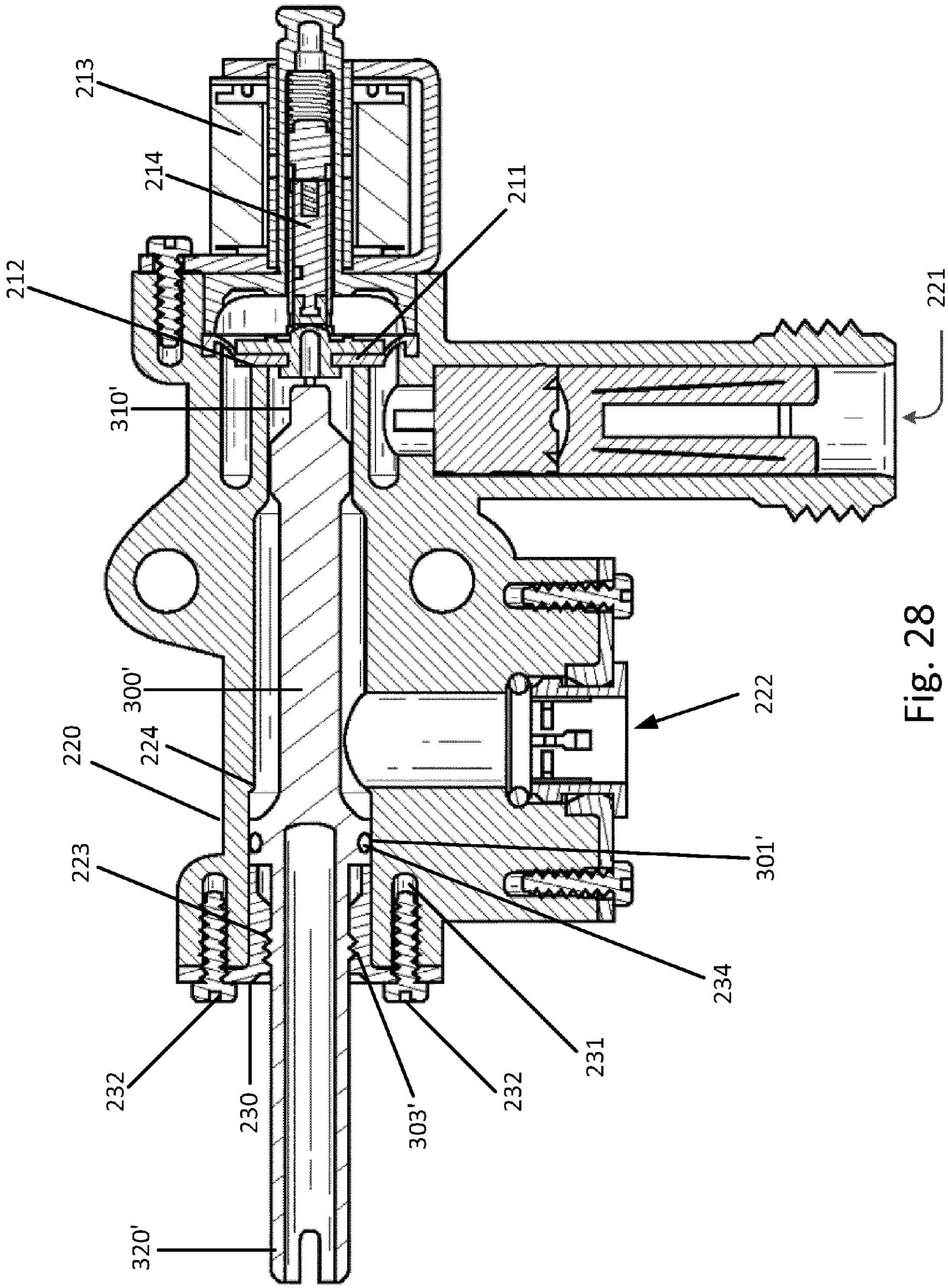

213
214
211
212
221
310'
300'
222
220
224
223
301'
234
231
232
230
303'
232
320'

Fig. 28

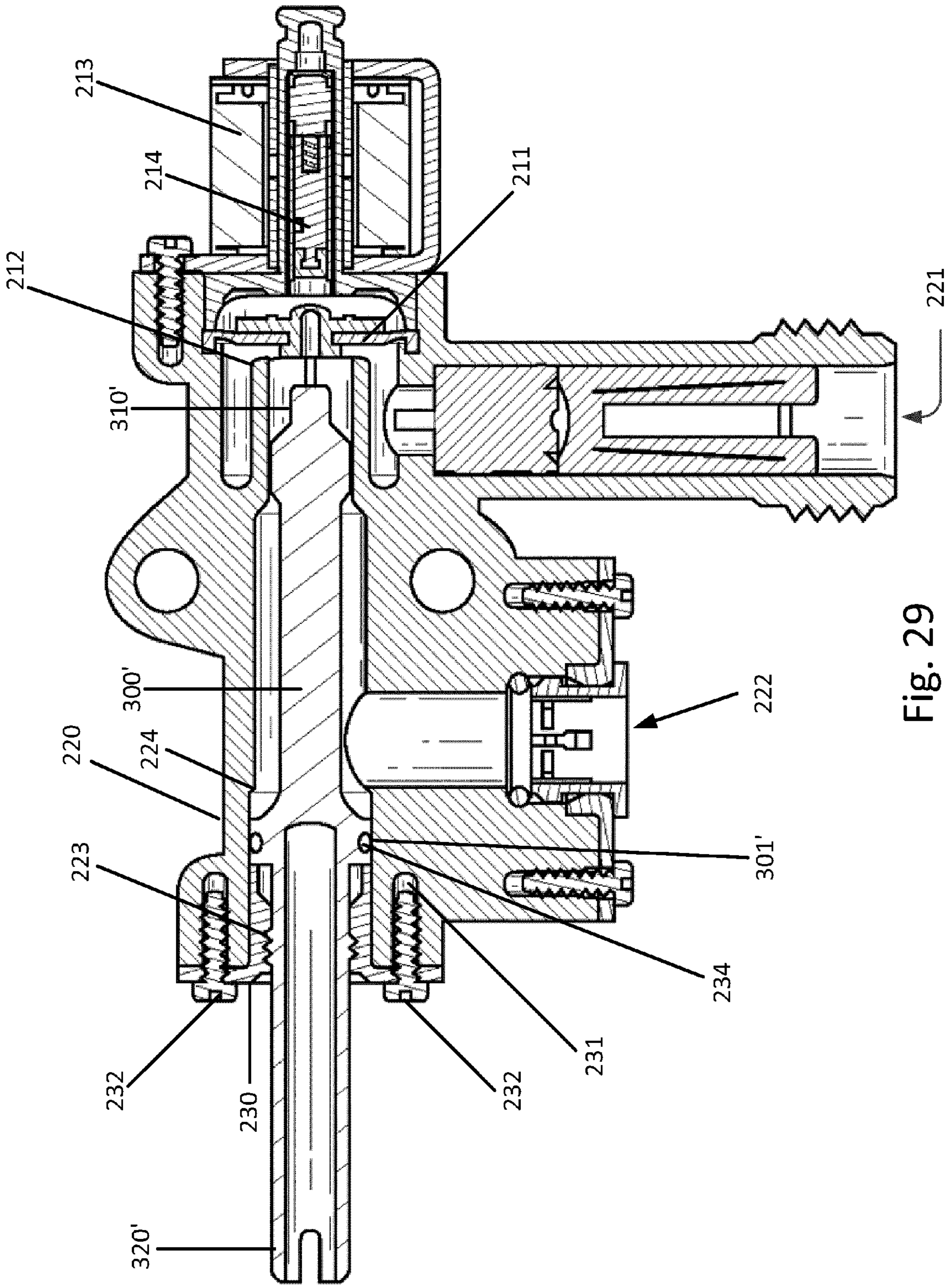

213
214
211
212
221
310'
300'
222
220
224
301'
223
234
231
232
230
232
320'

Fig. 29

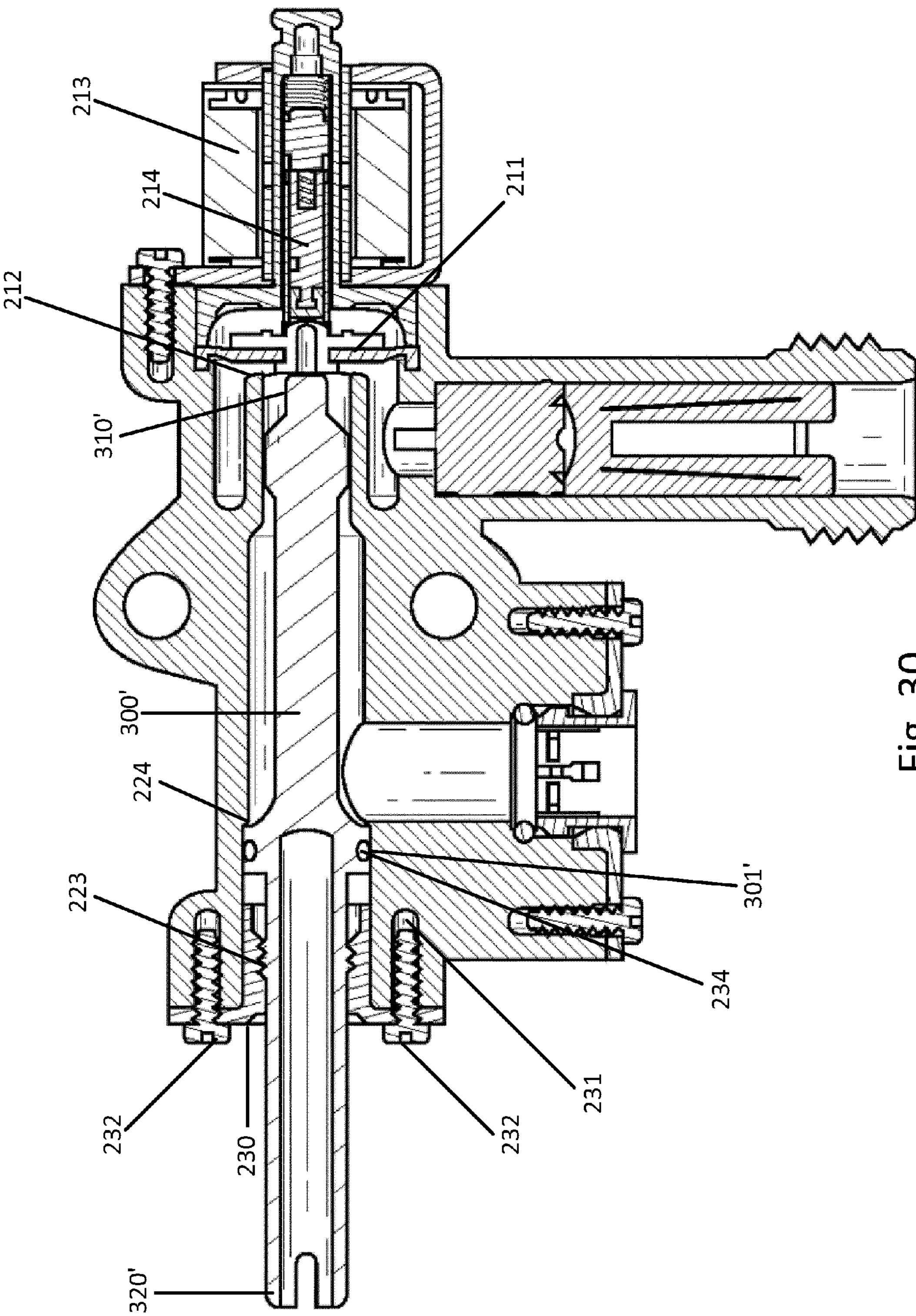


Fig. 30

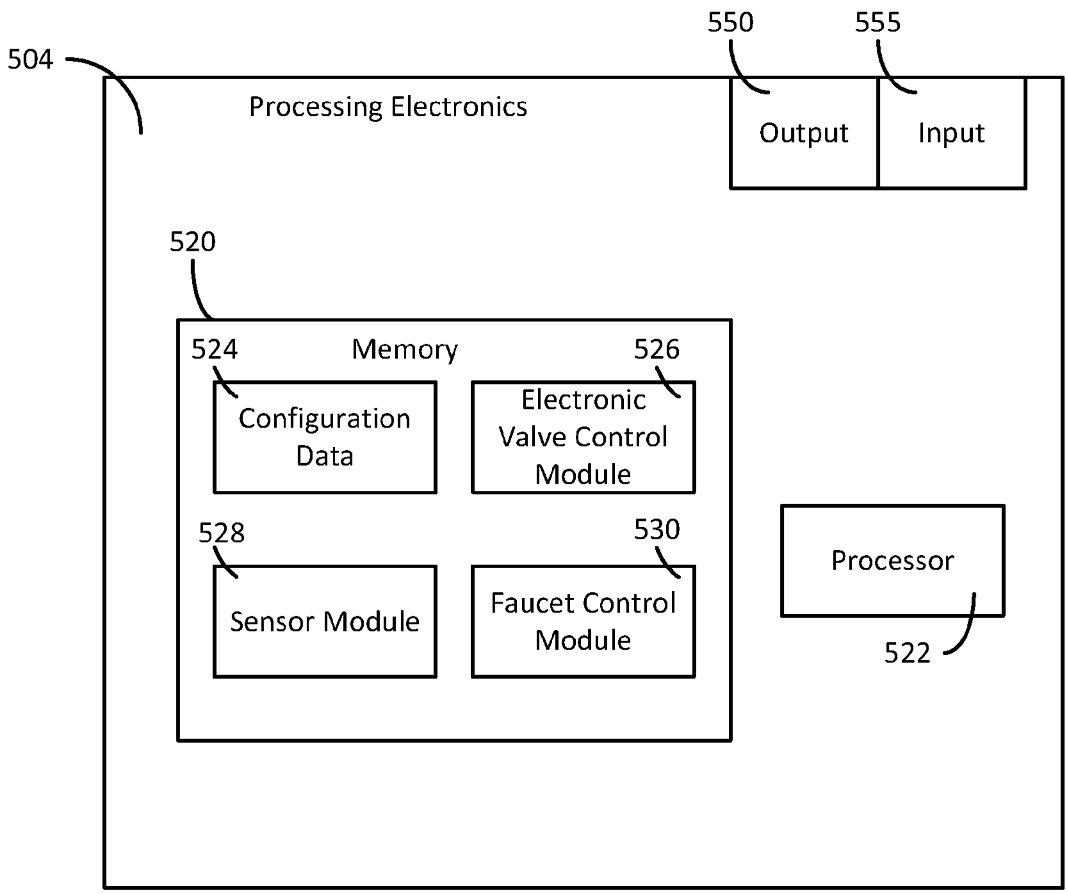
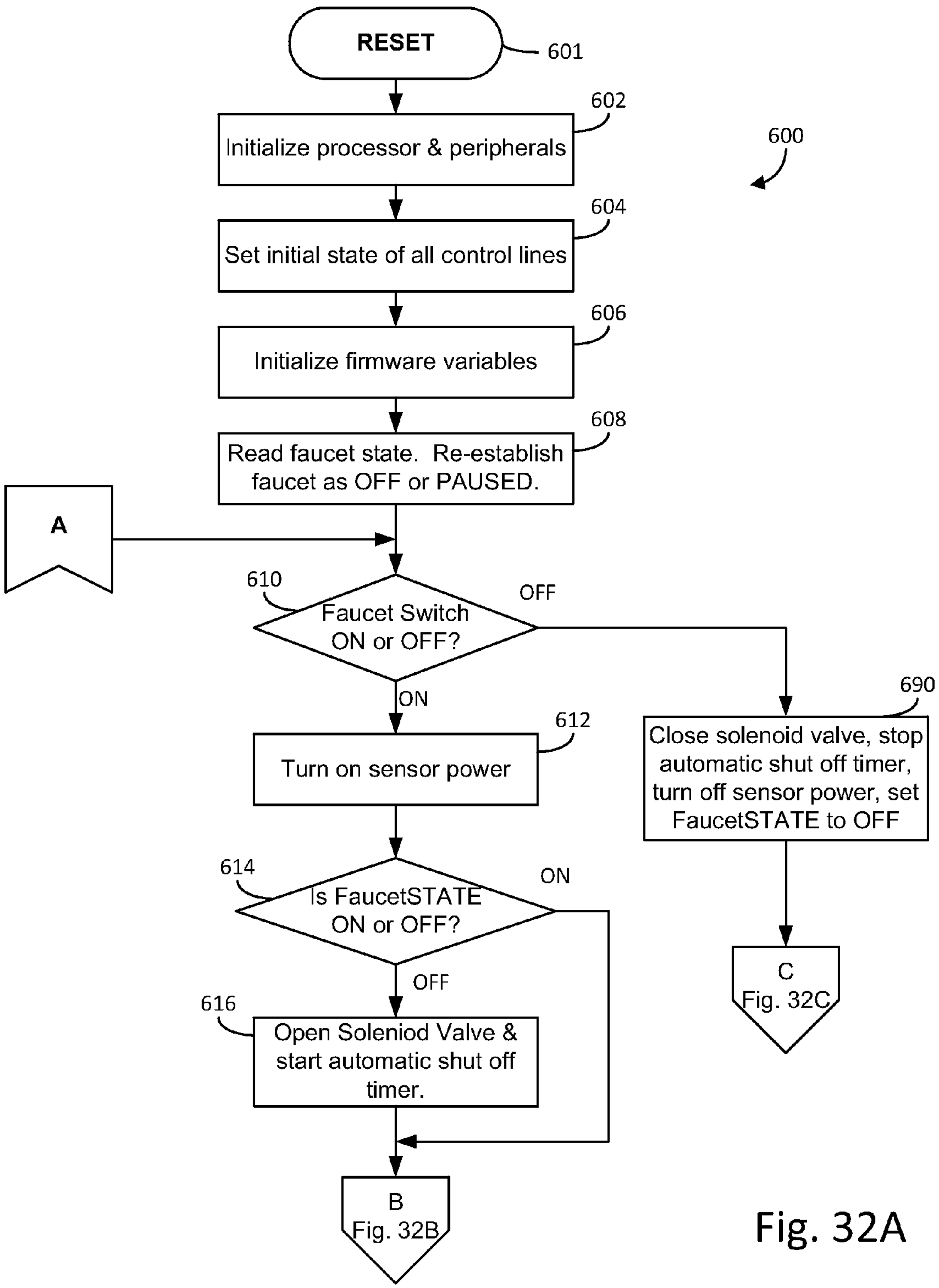

504
Processing Electronics
550
555
Output
Input
520
Memory
524
Configuration Data
526
Electronic Valve Control Module
528
Sensor Module
530
Faucet Control Module
Processor
522

FIG. 31



RESET
601
Initialize processor & peripherals
602
600
Set initial state of all control lines
604
Initialize firmware variables
606
Read faucet state. Re-establish faucet as OFF or PAUSED.
608
A
610
Faucet Switch ON or OFF?
OFF
ON
690
Close solenoid valve, stop automatic shut off timer, turn off sensor power, set FaucetSTATE to OFF
Turn on sensor power
612
614
Is FaucetSTATE ON or OFF?
ON
OFF
616
Open Soleniod Valve & start automatic shut off timer.
C
Fig. 32C
B
Fig. 32B

Fig. 32A

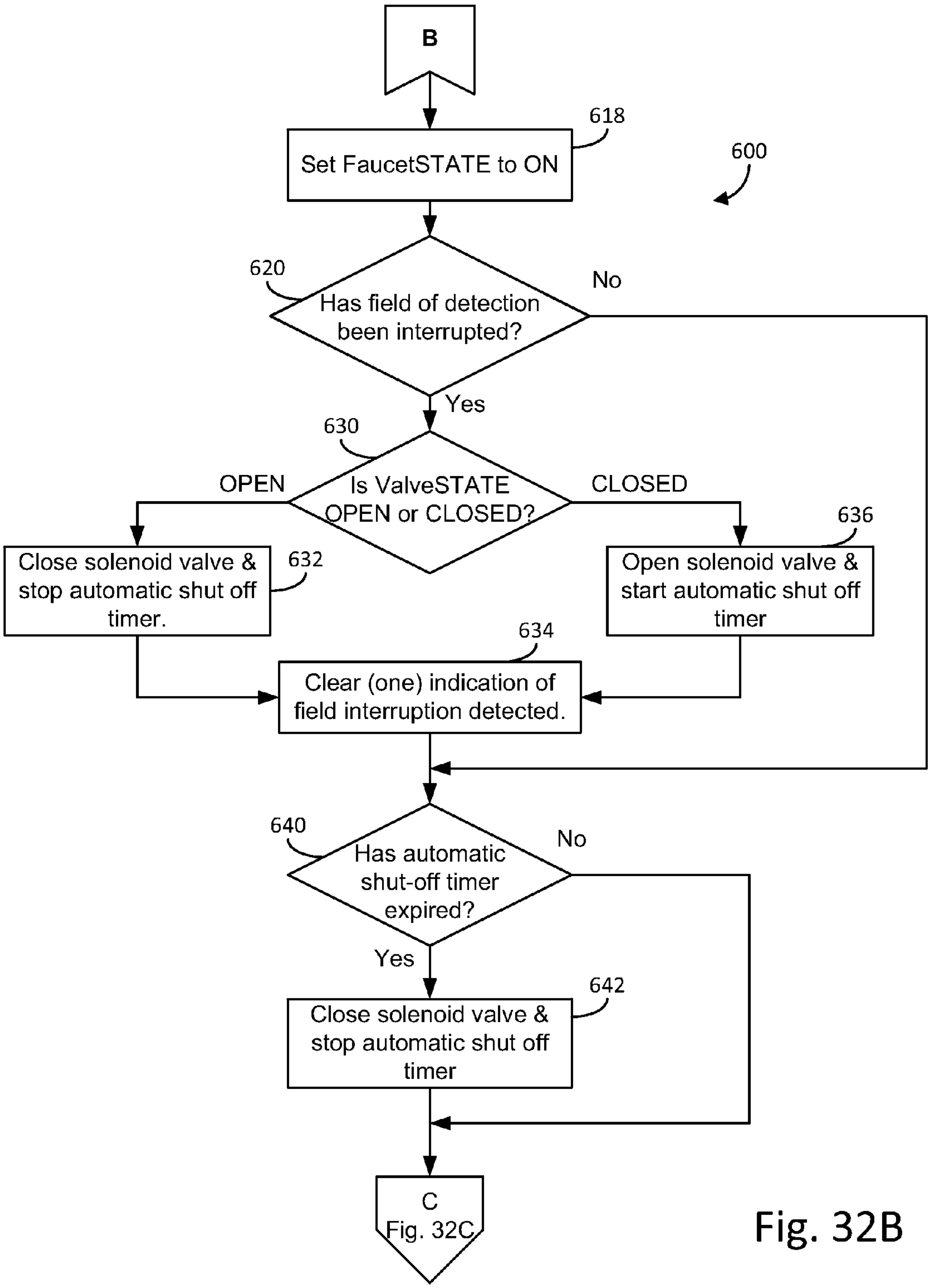
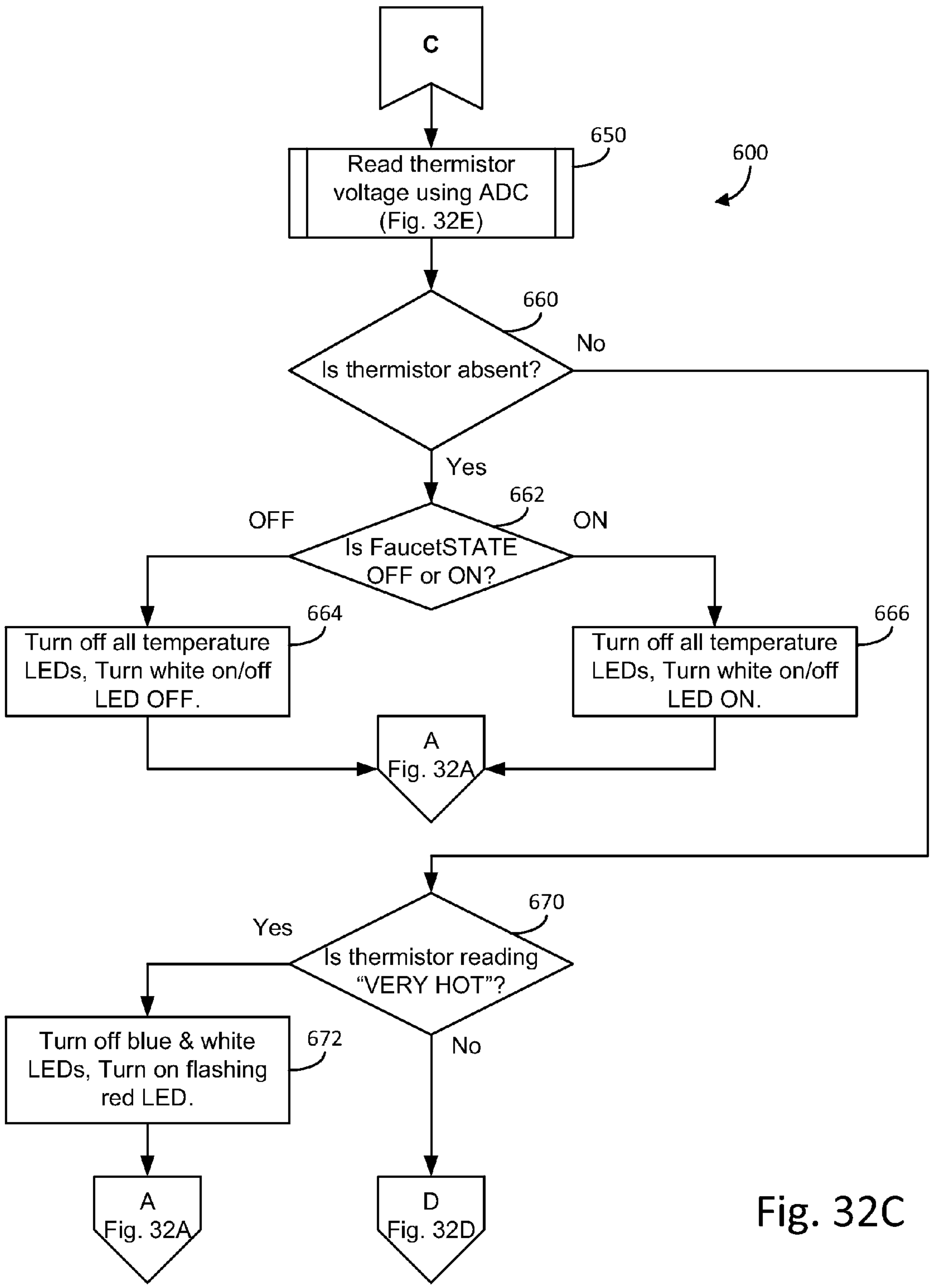

B
618
Set FaucetSTATE to ON
600
620
Has field of detection been interrupted?
No
Yes
630
Is ValveSTATE OPEN or CLOSED?
OPEN
CLOSED
Close solenoid valve & stop automatic shut off timer.
632
636
Open solenoid valve & start automatic shut off timer
634
Clear (one) indication of field interruption detected.
640
Has automatic shut-off timer expired?
No
Yes
642
Close solenoid valve & stop automatic shut off timer
C
Fig. 32C

Fig. 32B



C
Read thermistor voltage using ADC (Fig. 32E)
650
600
660
Is thermistor absent?
No
Yes
662
OFF
ON
Is FaucetSTATE OFF or ON?
664
666
Turn off all temperature LEDs, Turn white on/off LED OFF.
Turn off all temperature LEDs, Turn white on/off LED ON.
A
Fig. 32A
670
Yes
Is thermistor reading "VERY HOT"?
No
Turn off blue & white LEDs, Turn on flashing red LED.
672
A
Fig. 32A
D
Fig. 32D

Fig. 32C

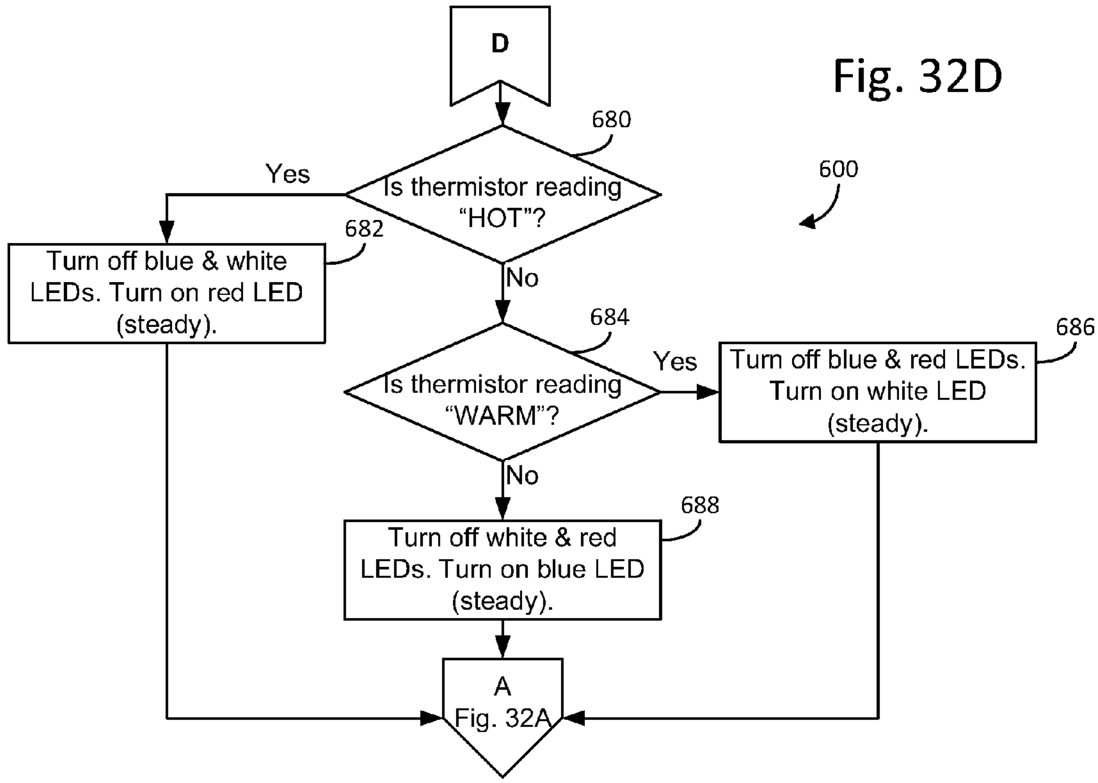


Fig. 32D

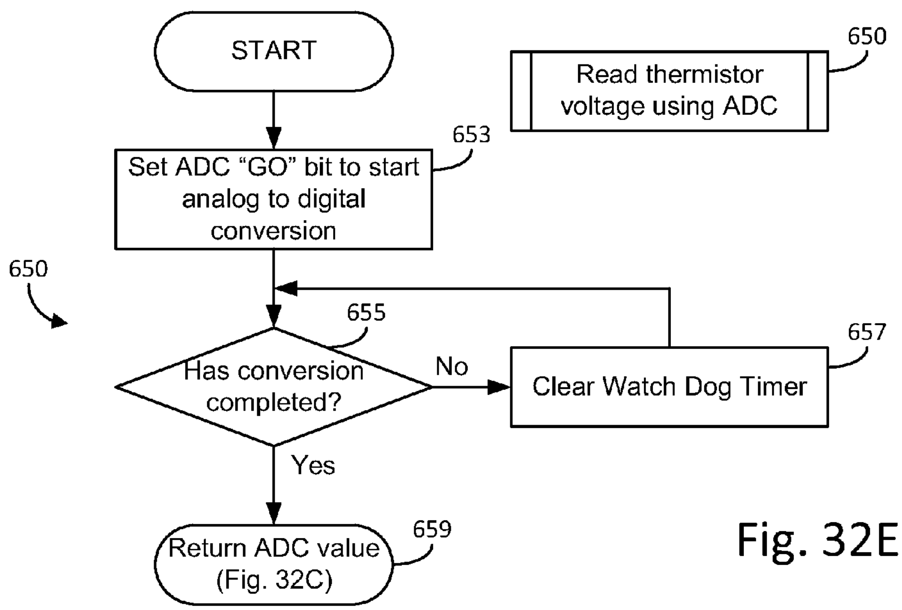


Fig. 32E

SYSTEM AND METHOD FOR MANUALLY OVERRIDING A SOLENOID VALVE OF A FAUCET

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from U.S. Provisional Patent Application No. 61/692,912, filed Aug. 24, 2012, from U.S. Provisional Patent Application No. 61/692,959, filed Aug. 24, 2012, and from U.S. Provisional Patent Application No. 61/692,966, filed Aug. 24, 2012, all of which are incorporated herein by reference in their entireties.

BACKGROUND

The present application relates generally to the field of faucets. More specifically, the present application relates to systems and methods for manually overriding a solenoid operated valve of a faucet.

This section is intended to provide a background or context to the invention recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

Some kitchen and bath faucets include a "touchless" control system. These touchless control systems may use magnetic, capacitive, or optical sensors to detect an object, such as a user's hands, underneath the faucet and, in response, to open or close a solenoid operated valve. In the event of a power failure, if the solenoid valve defaults to a closed position, the faucet will be rendered inoperable until power is resumed. Some touchless control systems use battery power or a combination of battery and line power to avoid losing function in the event of a power failure. However, these systems have disadvantages such as the requisite periodic replacement of batteries and/or an increased cost associated with installing and maintaining a dual system.

A need exists for improved technology, including technology that may address the above described disadvantages.

SUMMARY

An exemplary embodiment relates to a system for manually overriding a solenoid operated valve in an event of power failure is provided. The system includes a solenoid operated valve and a lifter. The solenoid operated valve includes a valve body including a sealing surface, a fluid inlet and a fluid outlet, a sealing element selectively separating the fluid inlet from the fluid outlet and a solenoid configured to selectively couple and decouple the sealing element to the sealing surface. The lifter is threadedly coupled to the solenoid operated valve. Rotation of the lifter relative to the valve body in a first direction causes the lifter to decouple the sealing element from the sealing surface.

Another exemplary embodiment relates to a lifter for manually overriding a solenoid operated valve in an event of power failure. The lifter includes a tip, a handle, and threads. The tip is formed at one end of the lifter and is configured to engage with a sealing element of the solenoid operated valve. The handle is formed at another end of the lifter, the handle configured to facilitate manual actuation of the lifter. The threads are provided to threadedly couple the lifter to the solenoid operated valve.

Yet another exemplary embodiment relates to a method of manually overriding a solenoid operated valve in an event of power failure. The solenoid operated valve includes a solenoid configured to selectively couple and decouple a sealing element to a sealing surface. The method includes inserting a lifter into a valve body. The valve body includes the sealing surface, a fluid inlet and a fluid outlet, and the fluid inlet and the fluid outlet are selectively separated by the sealing element. The method also includes rotating the lifter relative to the valve body in a first direction such that the lifter is threadedly coupled to the solenoid operated valve. The method further includes advancing the lifter, by threading, such that the lifter engages with the sealing element, causing the sealing element to decouple from the sealing surface.

Additional features, advantages, and embodiments of the present disclosure may be set forth from consideration of the following detailed description, drawings, and claims. Moreover, it is to be understood that both the foregoing summary of the present disclosure and the following detailed description are exemplary and intended to provide further explanation without further limiting the scope of the present disclosure claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide further understanding of the invention, are incorporated in and constitute a part of this specification, illustrate embodiments of the present disclosure, and together with the detailed description serve to explain the principles of the present disclosure. No attempt is made to show structural details of the present disclosure in more detail than may be necessary for a fundamental understanding of the present disclosure and the various ways in which it may be practiced.

FIG. **1** is a front view of a faucet, shown according to an exemplary embodiment.

FIG. **2** is a right, cross-sectional view of the faucet of FIG. **1** through the line A-A.

FIG. **3** is an enlarged partial view of the solid-circled area of the faucet of FIG. **2**.

FIG. **4** is an exploded view of a sensor, a sensor holder, and a wire cover disposed within the faucet of FIG. **1**.

FIG. **5** is a right elevation view of the sensor and the sensor holder of FIG. **4**.

FIG. **6** is a top plan view of the sensor and the sensor holder of FIG. **4**.

FIG. **7** is a top view of a spray insert of the faucet of FIG. **1**.

FIG. **8** is a bottom perspective view of the spray insert of FIG. **7**, including a protrusion on a tab of the spray insert shown according to an exemplary embodiment.

FIG. **9** is an exploded view of a system for detecting and communicating a position of a manual valve of the faucet of FIG. **1**, shown according to an exemplary embodiment.

FIG. **10** is a front, cross-sectional elevation view of the system of FIG. **9**.

FIG. **11** is a front, cross-sectional elevation view of the system of FIG. **9**, shown according to another exemplary embodiment.

FIG. **12** is a right, cross-sectional, elevation view of the system of FIG. **9**.

FIG. **13** is a perspective view of a manual valve and a ring of the system of FIG. **9** with a closed valve channel, according to an exemplary embodiment.

FIG. **14** is a perspective view of a manual valve and a ring of the system of FIG. **9** with an open valve channel, according to an exemplary embodiment.

FIG. **15** is a perspective, cross sectional view of the manual valve of FIG. **13** with a closed valve channel, according to an exemplary embodiment.

FIG. **16** is a side, cross sectional view of the manual valve of FIG. **13** with a closed valve channel, according to an exemplary embodiment.

FIG. **17** is a perspective, cross-sectional view of the manual valve of FIG. **14** with an open valve channel, according to an exemplary embodiment.

FIG. **18** is a side, cross-sectional view of the manual valve of FIG. **14** with an open valve channel, shown according to an exemplary embodiment.

FIG. **19** is an exploded perspective view an electronic valve of the faucet of FIG. **1** and a lifter for manually overriding the electronic valve, shown according to an exemplary embodiment.

FIG. **20** is a left elevation view of the electronic valve of FIG. **19**.

FIG. **21** is a front, cross-sectional view elevation of the electronic valve through a line B-B of FIG. **20**.

FIG. **22** is a left, cross-sectional view of the electronic valve through a line C-C of FIG. **21**.

FIG. **23** is an exploded perspective view of an electronic valve of the faucet of FIG. **1** and a lifter for manually overriding the electronic valve, shown according to another exemplary embodiment.

FIG. **24** is a left elevation view of the solenoid operated valve of FIG. **23**.

FIG. **25** is a front, cross-sectional elevation view of the electronic valve through a line D-D of FIG. **24**.

FIG. **26** is a perspective view of the lifter of FIG. **19**.

FIG. **27** is a front elevation view of the lifter of FIG. **26**.

FIG. **28** is a front, cross-sectional elevation view of the electronic valve of FIG. **23** in a closed position during normal operation, shown according to another exemplary embodiment.

FIG. **29** is a front, cross-sectional elevation view of the electronic valve of FIG. **23** in an open position during normal operation, shown according to another exemplary embodiment.

FIG. **30** is a front, cross-sectional elevation view of the electronic valve of FIG. **23** in an open position during override operation, shown according to another exemplary embodiment.

FIG. **31** is a block diagram of the processing electronics of the faucet of FIG. **1**, according to an exemplary embodiment.

FIGS. **32**A-E illustrate a flowchart of a process of controlling a faucet, shown according to an exemplary embodiment.

DETAILED DESCRIPTION

Before turning to the figures, which illustrate the exemplary embodiments in detail, it should be understood that the present disclosure is not limited to the details or methodology set forth in the description or illustrated in the figures. It should also be understood that the terminology is for the purpose of description only and should not be regarded as limiting. An effort has been made to use the same or like reference numbers throughout the drawings to refer to the same or like parts.

Referring generally to the figures, an exemplary embodiment may relate to a faucet including a sensor disposed within a faucet spout. The sensor, along with an electronic valve will allow the user to pause a flow of water from the faucet spout by engaging the sensor's field of detection. Flow will resume when the sensor's field of detection is engaged a second time. This configuration provides the user with a convenient, easy to use, touchless method of controlling the water flow. Moving the sensor internal to the spout provides a cleaner and aesthetically pleasing faucet profile; however, this configuration presents the added challenge of securing the sensor in the spout.

Referring generally to the figures, an exemplary embodiment may relate to a system for detecting and communicating a position of a mechanical valve in a faucet. The mechanical valve includes a valve channel configured to move between an open and a closed position. The system includes a switch configured to detect the position of the valve channel. The system further includes a ring located around the mechanical valve and configured to transfer motion of the valve channel to the switch. The system further includes an annunciator (e.g., an LED, LCD, audio, etc.) configured to indicate to a user the status of the mechanical valve position to a user and/or to an electronics system of the faucet.

Referring generally to the figures, an exemplary embodiment may relate to a manually-operated lifter configured to displace a sealing element off of a sealing surface by manual action in a faucet including a solenoid valve. In a touchless actuation system of a faucet, a sensor and an electronic valve, shown as a solenoid-operated valve, allow a user to pause a flow of water from the faucet spout by interrupting the sensor's field of detection. Flow will resume when the plane is broken a second time. In the event of a power failure, the solenoid-operated valve will default to a closed position, and the faucet will be rendered inoperable until power is resumed. The lifter allows a user to operate the faucet by manually moving the solenoid-operated valve from the closed position to an open position.

It should be noted that the term "exemplary" as used herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples). Accordingly, faucets having some or all of the features described above, or any combination or subcombination of the components and features described below, are contemplated within the scope of this disclosure.

Referring to the figures more particularly, as illustrated in FIG. **1**, an exemplary embodiment of a faucet **10** may include a faucet spout **1**, a faucet body **2**, a handle **3**, a base **4** for mounting upon a surface (not shown), and an electronic valve system **5** configured to pause (e.g., interrupt, inhibit, prevent, stop, etc.) and resume (e.g., permit, allow, etc.) a flow of fluid (e.g., water). The faucet spout **1** has a first or outlet end **7**, which defines an outlet **8** through which a fluid exits the faucet **10**. The faucet spout **1** further includes a second or inlet end **9** at which the faucet spout **1** is coupled to the faucet body **2**. In the exemplary embodiment, the handle **3** is operably coupled to a control stem **6** of a mechanical valve **410** (see, e.g., FIG. **10**) that is fluidly coupled to the electronic valve system **5**. The faucet body **2** may include a protruded portion **2**A disposed approximately perpendicular to a longitudinal axis of the faucet body **2**. The protruded portion **2**A is shown to support the mechanical valve **410** and the handle **3** via the control stem **6**.

The handle **3** is configured to at least partially control operation of the faucet **10**. According to the exemplary embodiment shown, the handle **3** may be coupled, via the control stem **6**, to a mechanical valve **410**, which controls the flow of fluid from a fluid source to the electronic valve system **5**. The mechanical valve **410**, in response to manipulation of the handle **3**, may mix incoming hot and cold fluids to output a fluid having a desired temperature. The mechanical valve

410 may be located upstream from the electronic valve system 5 with respect to a direction of fluid flow from a fluid source to the outlet 8. According to other embodiments, the mechanical valve may be downstream of the electronic valve system 5. When the handle 3 is in a first position (e.g., indicated by the solid line), the handle 3 is in a "non-operational" mode and fluid does not flow from the faucet spout 1. When the handle 3 is in a second position (e.g., indicated by the broken line), the handle 3 is in an "operational" mode and fluid flows through the mechanical valve to the electronic valve system 5 and, if the electronic valve 100, 200 is open and fluid is supplied to the faucet, then fluid flows from the outlet 8 of the faucet spout 1. In an exemplary embodiment, the mechanical valve 410 is disposed within the protruded portion 2A of the faucet body 2. In other embodiments, the mechanical valve 410 may be disposed in different locations, corresponding to the location of the handle 3.

Although in the illustrated exemplary embodiment, the handle 3 is mounted on a side of the faucet body 2, the handle 3 may be located in other positions, for example, on an opposite side of the faucet body 2 or along the surface (not illustrated) upon which the base 4 is mounted. This surface may be any surface including, but not limited to, a sink, a bathtub, shower wall, countertop, cabinet, appliance, etc. In an embodiment in which the handle 3 is located on the opposite side of the faucet body 2, the protruded portion 2A will also be located on the opposite side of the faucet body 2. In embodiments in which the handle 3 is located along the surface upon which the base 4 is mounted, or the handle 3 is mounted elsewhere on the faucet 10, the protruded portion 2A may be eliminated.

The electronic valve system 5 may pause and/or resume the flow of fluid in response to an open or a closed configuration of an electronic valve (e.g., electronically controlled valve, electromechanical valve, solenoid operated valve, etc.), shown as electronic valves 100, 200 (see FIGS. 28 and 29). According to the exemplary embodiment shown, the electronic valves 100, 200 include a solenoid. The electronic valve system 5 may also include any commercially available electronic valve and a sensor 20 disposed completely within, partially within or completely outside of the faucet spout 1 or faucet body 2. The electronic valve system 5 is in communication with the electronic valve 100, 200 and the sensor 20. In a preferred embodiment, the electronic valve is a normally closed solenoid such that in the event of a power failure the electronic valve closes and stops fluid flow. According to another embodiment, the electronic valve is a latching solenoid, which is held in an open or closed position by a magnet, and power is only required to switch between the open and closed positions. A latching solenoid requires less power to operate and, therefore, may be useful, for example, in a battery-operated electronic valve.

When the handle 3 is in the operational mode, a position of the electronic valve 100, 200 may pause or resume the flow of the fluid from the faucet spout 1. Specifically, when the electronic valve 100, 200 is in an open position, the fluid continues to flow from the faucet spout 1 when the handle 3 is in the operational mode. When the electronic valve 100, 200 is in a closed position, a flow of the fluid from the faucet spout 1 is paused, even if the handle 3 is in the operational mode. The open and closed positions of the electronic valve 100, 200 will be discussed in further detail below. When the handle 3 is in the non-operational mode, the fluid will not flow from the faucet spout 1 regardless of the position of the electronic valve 100, 200.

Referring briefly to FIGS. 19-25 and 28-30, exemplary embodiments of electronic valves 100, 200 are illustrated.

The electronic valves 100, 200 are shown to include a solenoid portion 110, 210 and a valve body 120, 220. The solenoid portion 110, 210 includes, but is not limited to, a sealing element 111, 211, a sealing surface 112, 212, a solenoid coil 113, 213, and a plunger 114, 214. The sealing element 111, 211 may be, for example, a diaphragm, a poppet, etc. The sealing element 111, 211 may include a pilot vent hole (not illustrated) and a second vent hole (not illustrated). The valve body 120, 220 includes an inlet 121, 221 and an outlet 122, 222. Other components of the solenoid portion 110, 210 that may be present in the electronic valve 100, 200 may not be illustrated or may not be provided with reference numerals (e.g., a spring, gasket, an o-ring, etc.). The exemplary embodiments illustrated will be discussed in more detail below.

In normal operation, the electronic valve 100, 200 may be in the open position or the closed position. In an exemplary embodiment, when the electronic valve 100, 200 is in the closed position (see, e.g., FIG. 28), the solenoid coil 113, 213 does not produce a magnetic field. In this configuration, the pilot vent hole is blocked by the plunger 114, 214, causing inlet pressure to pass through the second vent hole and push the sealing element 111, 211 onto the sealing surface 112, 212. In other words, the sealing element 111, 211 abuts an entire length (e.g., an annular circumference) of the sealing surface 112, 212 preventing the flow of fluid through the electronic valve 100, 200. Because fluid cannot flow from the inlet 121, 221 of the valve body 120, 220 to the outlet 122, 222 of the valve body 120, 220, fluid is not provided to the outlet 8.

When the electronic valve 100, 200 is in the open position (see, e.g., FIG. 29), the solenoid coil 113, 213 produces a magnetic field that draws the plunger 114, 214 towards the solenoid coil 113, 213. When plunger 114, 214 moves towards the solenoid coil 113, 213, a vent hole opens, allowing the sealing element 111, 211 to move away from the sealing surface 112, 212. In this configuration, pressure that was holding the sealing element 111, 211 onto the sealing surface 112, 212 is reduced, allowing inlet pressure to push the sealing element 111, 211 off of the sealing surface 112, 212. As a result, the sealing element 111, 211 no longer abuts an entire length of the sealing surface 112, 212 and fluid may flow between the sealing element 111, 211 and the sealing surface 112, 212. Because fluid can flow from the inlet 121, 221 of the valve body 120, 220 to the outlet 122, 222 of the valve body 120, 220, fluid may be provided to the outlet 8 of the faucet spout 1, if the handle 3 is in the operational mode.

Referring now to FIG. 2, the faucet 10 may include an internally mounted sensor, a sensor mounted to an underside of the faucet spout 1, and/or a sensor mounted proximate the apex of the faucet spout 1. A cross-sectional view of the faucet 10 through the line A-A of FIG. 1 is shown according to an exemplary embodiment. The faucet spout 1 has a first or outlet end 7 through which a fluid, for example, water, exits the faucet 10, and a second or inlet end 9 at which the faucet spout 1 is coupled to the faucet body 2. In between the outlet end 7 and the inlet end 9, the faucet spout 1 is shown to have a seamless sidewall 11 that extends along a curved longitudinal axis. The sidewall 11 defines an opening 13 along an underside of the faucet spout 1 proximate the zenith or apex of the faucet spout 1. As shown, the proximity of the opening 13 to the zenith of the underside of the faucet spout 1 causes the opening to be substantially horizontal. As further shown, the opening 13 may be slightly towards the outlet end 7 of the spout. In the illustrated exemplary embodiment, the opening 13 is formed as a punched opening. In alternative embodiments, the opening 13 may be machined or fabricated by any suitable method, for example, casting, cutting drilling, etc. The opening **13** may be covered by a transparent material such as glass or plastic.

A sensor **20** may be disposed completely within the faucet spout **1** along a curved portion of the sidewall **11** between the outlet end **7** and the inlet end **9** of the faucet spout **1**. The sensor **20** is disposed adjacent to the opening **13** of the faucet spout **1**. The sensor **20** may be any commercially available sensor of suitable size (i.e., a size capable of fitting inside of the faucet spout **1**). The sensor **20** may be selected, based in part, on factors such as a desired sensitivity, amount of power required to operate the sensor **20**, and cost considerations. For example, the sensor **20** may be configured such that the sensor **20** only detects (e.g., emits a signal in response to) objects within a predefined range. According to various embodiments, the range is less than 12 inches (30 cm), less than 10 inches (25 cm), or less than 8 inches (20 cm). According to an exemplary embodiment, the predefined range is less than 6 inches (15 cm). Reducing the sensitivity or range of the sensor allows a detection range (see, e.g., field of detection **70**, shown in FIG. **2**, detection region, etc.) to be defined that does not intersect the flow of fluid from the faucet spout **1** or the work region in or around the sink, thereby reducing accidental triggering of the sensor. The sensor **20** is operatively connected to the electronic valve **100**, **200**, e.g., wirelessly or via a wire **21** extending from the sensor **20** to the electronic valve system **5**. In some embodiments, the sensor **20** may be a receiver, discrete from or spaced apart from an emitter (e.g., transmitter, etc.). In other embodiments, the sensor **20** may be a receiver proximate or coupled to a transmitter. In other embodiments, the sensor **20** may be an emitter. In the exemplary embodiment shown, the sensor **20** includes both an emitter portion and a receiver portion.

Referring now to FIGS. **3-6**, a sensor holder **30** configured to position and retain the sensor **20** in the faucet spout **1** may be provided in the faucet **10**. The sensor holder **30** may be formed of any material including, but not limited to, plastic or metal. In a preferred embodiment, the sensor holder **30** is formed of plastic for cost considerations and characteristics such as moldability, durability, and corrosion resistance.

The sensor holder **30** includes a frame **31** configured to secure the sensor **20**. The frame **31** has a front end **31**A extending toward the outlet end **7** of the faucet spout **1** and a back end **31**B extending toward the inlet end **9** of the faucet spout **1**. A raised window **32** is disposed along and through a bottom or underside of the frame **31**. The raised window **32** is configured to engage the opening **13** of the faucet spout **1**. As shown, when the raised window **32** is positioned in the opening **13**, the sensor holder **30** is oriented in a substantially horizontal direction along a longitudinal axis of the spout proximate an apex of the spout and inhibits a horizontal motion of the sensor holder **30**.

The sensor holder **30** also includes at least one leg **33** disposed at the back end **31**B of the frame **31** and extending in a substantially vertical direction (e.g., substantially transverse or substantially perpendicular to a longitudinal axis of the sensor holder **30**). As illustrated in FIGS. **4-6**, an exemplary embodiment of the sensor holder **30** includes two legs **33**. In other embodiments, a different number of legs can be used, for example, one, three, four, etc. The legs **33** are configured to keep the back end **31**B of the frame **31** in either an up position (not illustrated) or a down position (see FIG. **3**) to inhibit a vertical motion of the sensor holder **30** and thus, securing the sensor **20** within the sensor holder **30**. When in the down position, the raised window **32** may engage with the horizontal opening **13** in the faucet spout **1**.

As shown in FIGS. **2** and **3**, the sensor holder **30** holds the sensor **20** in position over the opening **13**. The sensor **20** is held in a position slightly forward (e.g., toward a user when the faucet **10** is in an installed position) of the apex such that a light beam emitted from the sensor **20** passes through the opening **13** in the faucet spout **1**, and propagates downward and generally rearward. Accordingly, the light beam is directed away from fluid exiting the faucet spout **1** at the outlet end **7**, thereby reducing the possibility of inadvertent or accidental triggering of the sensor **20**. According to various embodiments, the light beam may be directed towards the faucet body **2**, a portion of the deck to which the faucet **10** is mounted in front of the faucet **10**, or rear wall of the sink basin. According to the exemplary embodiment shown, a user wishing to pause or resume the flow of fluid may wave a hand or object in a detection region under the faucet spout **1**, behind the flow of water, thereby reflecting the beam of light back to the sensor **20**. As shown in FIG. **2**, the field of detection **70** (e.g., detection zone, detection region, etc.) may be substantially defined by an underside of the faucet spout **1** above the outlet end **7** of the faucet spout **1**. According to another embodiment, a receiver may be located remotely from the sensor **20**, for example, on the faucet body **2** or another part of the faucet spout **1**, and a user wishing to pause or resume the flow of fluid may wave a hand or object in a detection region under the faucet spout **1**, behind the flow of water, thereby blocking the beam of light from reaching the receiver.

The sensor holder **30** further includes a forward tab **34** extending from the front end **31**A of the frame **31**. The forward tab **34** is held in place by a corresponding tab extending from a spray insert **40**. In a preferred embodiment, the forward tab **34** includes a slot **37**. However, the slot **37** is not required. In a preferred embodiment, the spray insert **40** includes a tab **41** (see FIGS. **7-8**). The tab **41** includes a substantially wedge-shaped protrusion **42**. However, the protrusion **42** may be any other suitable shape. The slot **37** and the protrusion **42** engage (see FIG. **3**) and are configured to prevent the sensor holder **30** from being inadvertently pushed further into and down the faucet spout **1**. A vertical motion of the sensor holder **30** is inhibited by the legs **33** and the forward tab **34**. According to another embodiment, the spray insert may include a tab and the sensor holder may include a corresponding slot.

The sensor **20** may be secured to the sensor holder **30** in a variety of ways. In an exemplary embodiment, the sensor holder **30** may be overmolded onto the sensor **20**. In another exemplary embodiment, the sensor **20** may include a plurality of holes **22** and the frame **31** may include a plurality of holes (not illustrated) corresponding to a number of holes **22** disposed in the sensor **20**. The plurality of holes **22** disposed in the sensor **20** and the plurality of holes disposed in the frame **31** are configured to align. In this embodiment, the sensor **20** is secured to the sensor holder **30** via a plurality of screws **23** that connect the sensor **20** and the sensor holder **30** via the plurality of holes **22** disposed in the sensor **20** and the plurality of holes disposed in the frame **31**. According to another embodiment, the sensor holder **30** may include a plurality of protrusions or bosses (not illustrated) that align with and are received in the plurality of holes **22**, thereby retaining the sensor **20** relative to the sensor holder **30**.

Referring now to FIG. **6**, the frame **31** of the sensor holder **30** may further include a plurality of projections **35** configured to engage with and further secure the sensor **20** and the wire **21** to the frame **31**. In addition, the frame **31** may include interior walls **36** having a contour corresponding to a perimeter of an area in which the sensor **20** connects to the wire **21**.

In another embodiment, the faucet **10** does not include the sensor holder **30**. Instead, the sensor **20** is held in place by fasteners, for example, screws, pins, plugs, clips, "Christmas trees," etc. For example, one fastener may be positioned at a forward or front end of the sensor **20** and another fastener may be positioned rearward or aft of the sensor **20**. However, due to a curvature of the faucet spout **1**, it may be difficult to drill or punch holes for the screws. Specifically, an inner curve of the faucet spout **1** tends to prevent a typical drill or punch from aligning perpendicularly to an inside of the inner curve of the faucet spout **1**. Thus, the sensor **20** might not be held in place by screws unless a right angle drill or a cam driven punch were utilized. Employing a sensor holder **30**, as described in the preferred embodiments, is intended to eliminate these problems.

In the embodiment shown, the faucet **10** may include a detachable or pull-out spray head **60** configured to direct a spray of fluid to a specific location. In this configuration, fluid moves through a hose passing within the faucet spout **1** and exits the faucet **10** through the spray head **60**. In such embodiments in which a spray head **60** is provided, the faucet **10** may include a wire cover **50** configured to protect the wire **21** connecting the sensor **20** to the electronic valve **100**, **200** from abrasion as the hose **62** travels through the faucet spout **1** as the spray head **60** is pulled out from and returned to the faucet spout **1**. In addition, the wire cover **50** protects the hose from abrasion that may result from contact with the sensor holder **30** and sensor **20**. The wire cover **50** may include a plurality of projections **51** disposed along a length of the wire cover **50**. Each projection **51** contains a recessed portion **52** configured to receive and secure to the wire **21**. The forward and rearward ends **53**, **54** of the wire cover **50** are curved to provide a ramp that guides the hose **62** over the wire cover **50**.

Referring now to FIG. **9**, the faucet **10** may further include a system for detecting and communicating a position of a mechanical valve in a faucet. An exploded view of a system **400** for detecting and communicating the position of the mechanical valve **410** is shown, according to an exemplary embodiment. The system **400** includes a ring **420**, a mounting surface **430**, a switch **440** (shown in FIGS. **10-14**), a balancing spring **450**, and an adjustment screw **460**. In the exemplary embodiment shown, the mounting surface **430** is a circuit board. According to one embodiment, the system **400** is a subsystem of the electronic valve system **5**.

Referring to briefly FIGS. **13-18**, the mechanical valve **410** includes a valve channel member **411** that is radially movable between an open position (see, e.g., FIGS. **14**, **17** and **18**) and a closed position (see, e.g., FIGS. **13**, **15** and **16**). The valve channel member **411** may have any suitable cross-sectional shape (e.g., square, rectangle, circular, oval, polygonal, box, etc.). As shown, the valve channel member **411** has a U-shaped cross-sectional shape. As used herein, "radially movable" refers to an in-and-out motion of the valve channel member **411** between an exterior and an interior of the mechanical valve **410**. The valve channel member **411** is coupled to a sealing component (not illustrated) within the mechanical valve **410**. The valve channel member **411** is configured to translate as the sealing component moves between "off" and "on" positions. In addition, the valve channel member **411** is in communication with an exterior of the mechanical valve **410**. The valve channel member **411** may be interconnected to the control stem **6** such that an adjustment of the temperature setting of the mechanical valve **410** (e.g., via the handle **3**) does not affect the position of the valve channel member **411**.

Referring now to FIGS. **9-14**, the ring **420** is configured to be generally coaxial with or disposed at least partially around the mechanical valve **410**. The ring **420** has an inner surface and an outer surface, with a diameter of the inner surface being smaller than a diameter of the outer surface. The switch **440** is mounted on the mounting surface **430** disposed on the inner surface of the ring **420**. This configuration allows the switch **440** to be positioned above the mechanical valve **410**. Thus, fluid from an inadvertent leak in the mechanical valve **410** will tend (e.g., by gravity) to flow down and away from the switch **440** to avoid or minimize damaging the switch **440**.

In a preferred embodiment, approximately radially opposite from the switch **440**, the ring **420** includes a protrusion **421** configured to engage with the balancing spring **450** and the adjustment screw **460**. Therefore, when the ring **420** is placed around the mechanical valve **410**, the valve channel member **411** is oriented approximately diametrically opposite from the switch **440**. The adjustment screw **460** is configured to engage with the valve channel member **411** and adjust a radial position of the ring **420** relative to an exterior of the mechanical valve **410**. Specifically, the valve channel member **411** transfers the motion of the mechanical valve **410** to the adjustment screw **460**, which, in turn, transfers the motion of the mechanical valve **410** to the ring **420** by adjusting the radial position of the ring **420** relative to the exterior of the mechanical valve **410**. The adjusting may be, for example, fine tuning the radial position of the ring **420** relative to the exterior of the mechanical valve **410**. The change in radial position of the ring **420** causes the switch **440**, mounted upon the ring **420**, to open and close accordingly in response to the translation of the valve channel member **411**.

The adjustment screw **460** is also configured to allow the system **400** to compensate for manufacturing variances. A position of the adjustment screw **460** can be set at the manufacturing factory and/or in the field after installing the faucet **10** or service parts thereof. The balancing spring **450** allows the system **400** to compensate for a weight of the ring **420** and the switch **440**.

In one embodiment, the mechanical valve **410** could be rotated, for example, 180 degrees such that the valve channel member **411** is located directly beneath (e.g., 0 degrees from) the switch **440**. However, this configuration would reverse a motion of the control stem **6**, and require modification of the method for adjusting the switch position, as described below. In another embodiment, the mechanical valve **410** could be configured such that the valve channel member **411** exits the top of the valve to directly contact the switch **440**.

According to the exemplary embodiment shown, as the mechanical valve **410** moves between the closed state to the open state, the valve channel member **411** translates, transferring the motion of the mechanical valve **410** to the adjustment screw **460** and thereby, the ring **420**, causing the switch **440** to actuate (e.g., open, close, etc.) accordingly. For example, when the mechanical valve **410** is in the closed state, the valve channel member **411** is in a closed position defined by an outer surface of the valve channel member **411** being substantially aligned with an outer surface of the mechanical valve **410** (see FIG. **13**). In this configuration, the valve channel member **411** pushes down on the adjustment screw **460**, which in turn pushes down on the ring **420** and compresses the balancing spring **450**. Accordingly, the ring **420** forces the switch **440** against the body or outer surface of the mechanical valve **410**, thereby closing the switch **440** (e.g., closed position, first state, second state, etc.). When the mechanical valve **410** is in the open state, the valve channel member **411** is in an open position defined by the outer surface of the valve channel member **411** being depressed or recessed such that the outer surface of the valve channel member **411** is disposed within the mechanical valve **410** (see FIG. **14**). In this configuration, the adjustment screw **460** follows the valve channel member **411** in response to the force of the balancing spring **450**. The balancing spring **450** pushes the ring **420** upward, away from the body or outer surface of the mechanical valve **410**, allowing the normally open switch **440** to return to an open position (e.g., open switch, second state, first state, etc.). According to another embodiment, the valve channel member **411** may be extended out of the mechanical valve **410** when the valve is in the closed state and may move inward to a position aligned with the outer surface of the mechanical valve **410** when the valve is moved to the open state.

The position or actuation of the switch **440** causes an annunciation of an on or off state. For example, the switch **440** may send a signal directly to an annunciator (discussed below) or to the electronic valve system **5**, either wirelessly or via wire **431** (see FIGS. **9**, **13**, and **14**), to indicate the on or off state. According to the exemplary embodiment shown, when the switch **440** is in the open position, the electronic valve system **5** turns on the annunciator, and when the switch **440** is in the closed position, the electronic valve system **5** turns off the annunciator.

In another embodiment, the valve channel member **411** may be depressed inward of, or flush with, the surface of the mechanical valve **410** when the mechanical valve **410** is in the closed state. The valve channel member **411** may move radially outward to a flush or proud position relative to the surface of the mechanical valve **410** when the mechanical valve **410** is in the open state. In such an embodiment, the valve channel member **411** may push on the adjustment screw **460**, in turn moving the ring **420** radially relative to the mechanical valve **410**, and drawing the mounting surface **430** towards the mechanical valve **410**, such that the switch **440** closes against the surface of the mechanical valve **410** when the mechanical valve **410** is in the open state, and the switch **440** is open when the mechanical valve **410** is in the closed state. In such an exemplary embodiment, a signal (e.g., voltage, pulse width, power, etc.) to the annunciator may be sent through the switch **440** such that when the switch **440** is in the open position, the electronic valve system **5** does not complete a circuit to the annunciator, and, therefore, the annunciator is turned off. When the switch **440** is in the closed position, the electronic valve system **5** completes the circuit to the annunciator, and, therefore, the annunciator is turned on. In other words, when the manual valve is in the closed state or non-operational mode, the annunciator is turned off, but when the manual valve is in the open state or operational mode, the annunciator is turned on.

In embodiments in which the switch **440** is adjacent or proximate the adjustment screw **460**, the end of the valve channel member **411** that abuts the adjustment screw **460** may be configured to move into or towards the mechanical valve **410** when the mechanical valve moves from a closed state to an open state. The switch **440** may then close against the body or outer surface of the mechanical valve **410**, causing the annunciator to turn on. The configuration of the actuation could be reversed such that the end of the valve channel member **411** that abuts the adjustment screw **460** may be configured to move out off or away from the mechanical valve **410** when the mechanical valve moves from a closed state to an open state. The switch **440** may be a normally open switch that then opens away from the body or outer surface of the mechanical valve **410**, causing the annunciator to turn on (e.g., via the electronic valve system **5**, processing electronics, etc.).

According to various other embodiments, the switch **440** may be disposed on the ring **420** and mounting surface **430** such that the switch **440** actuates against an inner surface of the faucet body **2** (e.g., the protruded portion **2**A). For example, the switch **440** may be disposed on an outer surface of the ring **420**.

Having a switch **440** provides a low-cost, reliable, and robust indicator of state. In another embodiment, the switch **440** may be replaced with a potentiometer or similar device capable of indicating a relative position of the valve channel member **411**. The relative position of the valve channel member **411** may be defined, for example, from 0% to 100% open. The position of the valve channel member **411** is correlated (e.g., proportional to, etc.) to a flow through the mechanical valve **410** (i.e., off, low, medium or high). In yet another embodiment, the adjustment screw **460** and/or the balancing spring **450** may be eliminated.

The annunciator is configured to indicate to the user, for example, whether the electronic valve system **5** is in an active mode or an inactive mode (e.g., off mode, hibernation mode, etc.) or some combination thereof (e.g., sleep mode, etc.), whether the mechanical valve is in an open state or a closed state, etc. The annunciator may be a visual indicator such as a light, a single colored LED, multiple colored LEDs (e.g., a red LED for hot fluid and a blue LED for cold fluid), an LCD, a display screen, etc. The display screen may provide information such as temperature, flow, date, time, etc. As illustrated, the annunciator is an LED **433**. Alternatively, the annunciator may be an audio indicator such as a beep or tone indicating activation or deactivation of the electronic valve system **5**. In addition, both a visual and an audio annunciator may be used simultaneously. The annunciator may be incorporated onto the mounting surface **430** (i.e., the same mounting surface as the switch **440**). Alternatively, the annunciator may be located at a different position, for example, at the base **4** or at a different position along the longitudinal axis of the faucet body **2**. The position of a visual annunciator is preferably in a position to be easily visible to a user. For example, the light from LED **433** may be visible through a translucent cover **435**.

Based on a detected closed or open state of the mechanical valve **410**, the electronic valve system **5** may take actions to conserve power. For example, if the mechanical valve **410** is closed, the electronic valve system **5** may enter an off mode. In the off mode, the electronic valve system **5** may turn off (e.g., reduce or remove power from) the annunciator, the sensor **20**, and/or the electronic valve **100**, **200**. In other words, the electronic valve system **5** essentially shuts down, except for a small amount of electricity reserved to reactivate the electronic valve system **5**, for example, in response to the mechanical valve **410** being manipulated to the open state. If the annunciator is off (i.e., the electronic valve system **5** is in an off mode), notice is provided to the user that the mechanical valve **410** must be opened before the faucet **10** will provide fluid. When the user manipulates the control stem **6** to open the mechanical valve **410**, fluid is provided to the electronic valve **100**, **200**, and the electronic valve system **5** is reactivated. When the electronic valve system **5** is reactivated or in the active mode, the electronic valve system **5** energizes (e.g., opens) the electronic valve and provides fluid to the user. The user can then pause or resume fluid flow as desired by triggering the sensor **20**.

In contrast, if the annunciator is on (e.g., the electronic valve system **5** is in active mode), notice is provided to the user that the mechanical valve **410** is already opened and thus, the user need only trigger the sensor **20** by engaging the sensor's field of detection **70** in order to resume fluid flow. Thus, the system **400** may detect a closed or open state/

position of the mechanical valve **410** and communicate the information to the electronic valve system **5** and/or the user.

A method for touchless actuation of the faucet **10** will now be discussed. As previously described, when the handle **3** is in the operational mode, a position of the electronic valve **100**, **200** may pause or resume the flow of the fluid from the faucet spout **1**. Specifically, when the electronic valve **100**, **200** is in the open position, the fluid continues to flow from the faucet spout **1** when the handle **3** is in the operational mode. When the electronic valve **100**, **200** is in the closed position, a flow of the fluid from the faucet spout **1** is paused, even if the handle **3** is in the operational mode. When the handle **3** is in the non-operational mode, the fluid will not flow from the faucet spout **1** regardless of the position of the electronic valve **100**, **200**.

When the mechanical valve **410** is in the operational mode and the electronic valve **100**, **200** is in the open position, the flow of fluid from the faucet spout **1** may be paused by engaging or triggering the sensor **20**. The sensor **20** may be triggered by using an object, for example, a user's hand or a dish, to engage the field of detection **70** of the sensor **20** at a first time. In one embodiment, the sensor **20** may be an infrared sensor. When an infrared sensor is utilized, engaging the sensor's field of detection **70** refers to interrupting (e.g., blocking, etc.) or reflecting a beam of infrared light that is projected by an emitter. In other embodiments, a different type of sensor (e.g., ultrasonic, capacitive, etc.) may be utilized. One of ordinary skill in the art would appreciate that the sensor's field of detection may be engaged in a different manner unique to the type of sensor utilized. When the object engages the sensor's field of detection **70**, the sensor **20** sends a signal to the electronic valve system **5**, and the electronic valve system **5** causes the electronic valve **100**, **200** to move from the open position (see, e.g., FIG. **29**) to the closed position (see, e.g., FIG. **28**).

The flow of fluid from the faucet spout **1** may be resumed by retriggering the sensor **20** by using an object, for example, a user's hand or a dish, to engage the field of detection **70** of the sensor **20** at a second time. When the object engages the field of detection **70** of the sensor **20**, the sensor **20** sends a signal to the electronic valve system **5**, and the electronic valve system **5** causes the electronic valve **100**, **200** to move from the closed position (see, e.g., FIG. **28**) to the open position (see, e.g., FIG. **29**). The object used to engage the sensor's field of detection the second time may be the same or different from the object used to engage the sensor's field of detection the first time.

As previously stated, when the mechanical valve **410** is in the closed state or the non-operational mode, the fluid will not flow from the outlet **8** regardless of the position of the electronic valve. Thus, it is desirable for the electronic valve system **5** to be able to detect and communicate a condition, either open state or closed state, of the mechanical valve **410**.

According to various exemplary embodiments, electronic valve system **5** may include processing electronics configured to support and enable the system and methods such as those described in this disclosure. Referring to FIG. **31**, a detailed block diagram of processing electronics **504** of FIG. **1** is shown, according to an exemplary embodiment. Processing electronics **504** includes a memory **520** and processor **522**. Processor **522** may be or include one or more microprocessors, an application specific integrated circuit (ASIC), a circuit containing one or more processing components, a group of distributed processing components, circuitry for supporting a microprocessor, or other hardware configured for processing. According to an exemplary embodiment, processor **522** is configured to execute computer code stored in memory **520** to complete and facilitate the activities described herein. Memory **520** can be any volatile or non-volatile memory device capable of storing data or computer code relating to the activities described herein. For example, memory **520** is shown to include modules **524-530** which are computer code modules (e.g., executable code, object code, source code, script code, machine code, etc.) configured for execution by processor **522**. When executed by processor **522**, processing electronics **504** is configured to complete the activities described herein. Processing electronics **504** includes hardware circuitry for supporting the execution of the computer code of modules **524-530**. For example, processing electronics **504** includes hardware interfaces (e.g., output **550**) for communicating control signals (e.g., analog, digital) from processing electronics **504** to electronic valve **100**, **200**. Processing electronics **504** may also include an input **555** for receiving, for example, signals from sensor **20**, mechanical valve detection system **400**, or for receiving data or signals from other systems or devices.

Memory **520** includes configuration data **524**. Configuration data **524** includes data relating to the electronic valve system **5**. For example, configuration data **524** may include solenoid data which may be used by the electronic valve control module **526** to control the operation of the electronic valve **100**, **200**. For example, configuration data **524** may include sensor data which may be used by the sensor module **526** to control the operation of the sensor **20** or to interpret signals from the sensor **20**.

Memory **520** is further shown to include an electronic valve control module **526**, which includes logic for operating or sending signals to the electronic valve **100**, **200**. For example, in an embodiment in which the electronic valve **100**, **200** includes a solenoid, the electronic valve control module **526** may include logic for controlling the solenoid valve.

Memory **520** is further shown to include a sensor module **528**, which includes logic for controlling or interpreting signals from/to the sensor **20**. For example, the sensor module **528** may include logic for turning the sensor **20** on or off. For example, the sensor module **528** may include logic for interpreting signals received by the sensor **20** (e.g., distinguishing signal from noise, etc.). For example, the sensor module **528** may include logic for controlling or generating signals (e.g., infrared beam, ultrasonic waves, etc.) emitted by the sensor **20**.

Memory **520** is further shown to include a faucet control module **530**, which includes logic for controlling the electronic valve system **5**. For example, the faucet control module **530** may include logic for determining a faucet state or mode based on various inputs or events (e.g., handle position, elapsed time, interruption of the field of detection **70** of the sensor **20**, etc.). For example, the faucet control module **530** may include logic for determining and enunciating information to a user (e.g., faucet state, water temperature, etc.).

Referring to FIGS. **32**A-E, a flowchart of a process **600** for controlling a faucet (e.g., the faucet **10**), is shown according to an exemplary embodiment. Although the process **600** may be started at any point, for the purposes of clarity, the process **600** is described as beginning at Reset (step **601**). At Reset, power may be initially provided to the electronics of the faucet, for example, at initial installation or after recovering from a power outage. The process **600** includes the steps of initializing the processor and peripherals (step **602**), setting the initial state of all control lines (step **604**), initializing firmware variables (step **606**), reading the faucet state, and reestablishing faucet as OFF or PAUSED (step **608**). Reestablishing the faucet as OFF or PAUSED ensures that fluid does not flow or begin to flow through the electronic valve **100**, **200** after interruption of electrical power to the faucet **10**.

The process **600** is further shown to include the step of determining whether the faucet switch is ON or OFF (step **610**). For example, the process **600** may determine whether the handle **3** is in an operational or non-operational mode (e.g., open or closed position) based on the state of the switch **440** of the mechanical valve detection system **400**. If the faucet switch is determined to be ON, then the sensor **20** is turned on (step **612**), or kept on if the sensor **20** is already on.

Process **600** is further shown to include the step of determining whether the faucet state is ON or OFF (step **614**). If the faucet state is OFF, then the process **600** opens the solenoid valve starts the automatic shutoff timer (step **616**) and sets the faucet state to ON (step **618**). If the faucet state is determined to be ON (step **614**), then the process proceeds directly to step **618** because the solenoid valve and the automatic shutoff timer should have already been actuated.

Referring to FIG. **32**B, the process **600** is further shown to include the step of determining whether the field of detection has been interrupted (step **620**). For example the process **600** may determine whether field of detection **70** has been interrupted (e.g., by a user, by an object, etc.) in response to a signal that the sensor **20** has received a beam reflected back to it or had a beam blocked from it. If the process **600** determines that the field of detection has been interrupted, then the process **600** proceeds to determine if the valve state is OPEN or CLOSED (step **630**). If the valve state is OPEN, then the process **600** closes the solenoid valve, stops the automatic shutoff timer (step **632**), and clears an indication of field interruption detection (step **634**). If the valve state is determined to be CLOSED, then the process **600** opens the solenoid valve, starts the automatic shutoff timer (step **636**), and clears the indication of field interruption detection (step **634**). According to an exemplary embodiment, interrupting the field of detection **70** a first time causes the electronic valve **100**, **200** to close and to stop the flow of fluid through the electronic valve **100**, **200**, and interrupting the field of detection **70** a second time causes the electronic valve **100**, **200** to open and to permit the flow of fluid through the electronic valve **100**, **200**.

The process **600** is shown to further include the step of determining whether an automatic shutoff timer has expired (step **640**). If the automatic shutoff timer has expired and the process **600** proceeds to close the solenoid valve, to stop the automatic shutoff timer (step **642**) and to proceed to read a fluid temperature, for example, a thermistor voltage using an analog to digital converter (step **650**). If the process **600** has determined that the automatic shutoff timer has not expired, then the process **600** proceeds directly to step **650**. Having an automatic shutoff timer conserves resources such as water and prevents overflowing of a sink or basin by shutting off the flow of fluid after a predetermined amount of time. According to various embodiments, the automatic shutoff timer may expire after one minute, two minutes, three minutes, five minutes, six minutes, ten minutes, or any other suitable amount of time. According to an exemplary embodiment, the automatic shutoff timer may expire after four minutes. The expiry time of the automatic shutoff timer may be a preconfigured feature of the electronic valve system **5** (e.g., programmed at the factory) or a feature that is selectable and reprogrammable by an end-user.

Referring to FIGS. **32**C-E, the process **600** may include steps (e.g. steps **650-688**) for determining the temperature of the fluid supplied to the outlet **8** of the faucet **10** and annunciating that information to a user. Temperature information may be annunciated to the user through an annunciator (e.g., a display, an LCD, a system of one or more indicators, color-coded LEDs, LED **433**, a speaker, an electro-acoustic transducer, etc.).

Referring now more specifically to FIGS. **32**C and **32**E, the process **600** is shown to include a subroutine for reading a thermistor voltage using an analog to digital converter (ADC) (steps **653-659**). While a thermistor is described in the exemplary embodiment, according to various other embodiments, any suitable temperature sensor (e.g., thermometer, thermocouple, thermostatic elements, etc.) may be used. The thermistor may be located anywhere that may provide the temperature of the fluid, for example, in the spout **1**, the body **2**, upstream of the mechanical valve **410**, between the mechanical valve **410** and the electronic valve **100**, **200**, etc. According to an exemplary embodiment, the thermistor is located proximate the electronic valve **100**, **200**, downstream of the electronic valve **100**, **200**.

The subroutine **650** is shown to include the step of setting analog-to-digital converter "GO" bit to start analog-to-digital conversion (step **653**). Subroutine **650** is further shown to determine whether analog-to-digital conversion has been completed (step **655**). If analog-to-digital conversion has not been completed then the subroutine **650** dwells. As shown the subroutine **650** may include a watchdog timer reset (clear) (step **657**). The analog-to-digital conversion has been completed, and the resulting ADC value is returned to the process **600** at step **660** (step **659**). According to one embodiment, if the analog-to-digital conversion fails, the watchdog timer of step **657** returns a value or signal to step **660** of the process **600**.

Returning to FIG. **32**C, process **600** is shown to determine whether the thermistor is absent (step **660**). According to one embodiment, the thermistor may be determined absent if the watchdog timer of step **657** indicates that the analog-to-digital conversion has failed. According to another embodiment, the thermistor may be determined absent if the analog-to-digital conversion returns an absurd or extreme value (e.g., 999 counts), which may indicate that the electronic valve system **5** does not include a thermistor. If the process **600** determines that the thermistor is absent, then the process **600** determines if the faucet state is ON or OFF (step **662**). If the faucet state is OFF, then all of the temperature annunciators (e.g., temperature LEDs, red and blue LEDs, etc.) are turned OFF, and the faucet state annunciator (e.g., a white LED, and on/off LED, etc.) is turned OFF (step **664**). If the faucet state is ON, then all of the temperature annunciators (e.g., temperature LEDs, red and blue LEDs, etc.) are turned OFF, and the faucet state annunciator (e.g., a white LED, and on/off LED, etc.) is turned ON (step **666**). Referring to steps **610-618**, and foreshadowing step **690**, the faucet state indicates whether the faucet switch (e.g., switch **440**), and, therefore, the valve stem **6** and handle **3**, are in an open or closed position. Accordingly, the faucet state annunciator (e.g., white LED, LED **433**, etc.) will annunciate to a user whether a user should control the faucet **10** by using the handle **3** or by engaging the field of detection **70** of the sensor **20**. After either step **664** or step **666**, the process **600** again determines whether the faucet switch is ON or OFF (step **610**).

If the process **600** determines that a thermistor is not absent (e.g., present) (step **660**), then the process determines the temperature of the fluid and annunciates the fluid temperature to a user. Such temperature annunciation may inform a user if the fluid is cool enough to drink, warm or hot enough to wash dishes, or so hot as to provide annoyance or pain (e.g., very hot, extremely hot, etc.), etc. Exemplary temperature ranges are provided below; however, other temperatures may be selected in other embodiments.

If the process **600** determines that thermistor is reading a "very hot" fluid temperature (step **670**), then the process **600** turns off the cold (e.g., cool, tepid, etc.) annunciator (e.g., a blue LED) and the warm (e.g., neutral, mild, etc.) annunciator (e.g., a white LED), and flashes a hot annunciator (e.g., a red LED) (step **672**). For example, if the process **600** determines that the fluid temperature exceeds a predetermined "very hot" value (e.g., 120° F., 125° F., 48° C., 50° C., 52° C., some value between 118F and 125F, some value between 48° C. and 52° C., etc.), then the process annunciates the very hot fluid temperature. According to another embodiment, the "very hot" fluid temperature may be annunciated with its own color LED, a combination of colored LEDs, or the temperature may be caused to be shown on a display, etc. According to one embodiment, the rate at which the LED flashes may correspond or correlate to the temperature of the fluid. For example, faster flashing may annunciate a hotter fluid temperature. Then process **600** proceeds to determine is the faucet switch is ON or OFF (step **610**).

Referring to FIG. **32**D, if the thermistor reading is not "very hot" (e.g., does not exceed the "very hot" predetermined value) then the process **600** determines whether the thermistor is reading a "hot" fluid temperature (step **680**). If the process **600** determines that thermistor is reading a "hot" fluid temperature, then the process **600** turns off the cold annunciator (e.g., a blue LED) and the warm annunciator (e.g., a white LED), and steadily illuminates the hot annunciator (e.g., a red LED) (step **682**). For example, if the process **600** determines that the fluid temperature exceeds a predetermined "hot" value (e.g., 95° F., 100° F., 105° F., 35° C., 40° C., 45° C., some value between 95° F. and 105° F., some value between 35° C. and 45° C., etc.), then the process **600** annunciates the hot fluid temperature. According to another embodiment, temperature may be caused to be shown on a display, etc. Process **600** then proceeds to determine if the faucet switch is ON or OFF (step **610**).

If the thermistor reading is not "hot" (e.g., does not exceed the "hot" predetermined value) (step **680**), then the process **600** determines whether the thermistor is reading a "warm" fluid temperature (step **684**). If the process **600** determines that thermistor is reading a "warm" fluid temperature, then the process **600** turns off the cold annunciator (e.g., a blue LED) and the hot annunciator (e.g., a red LED), and turns on the warm annunciator (e.g., a white LED) (step **686**). For example, if the process **600** determines that the fluid temperature exceeds a predetermined "warm" value (e.g., 75° F., 80° F., 85° F., 24° C., 25 C, 27° C., 30° C., some value between 75° F. and 85° F., some value between 24° C. and 30° C., etc.), then the process **600** annunciates the warm fluid temperature. According to another embodiment, temperature may be caused to be shown on a display, etc. Process **600** then proceeds to determine if the faucet switch is ON or OFF (step **610**).

If the thermistor reading is not "warm" (e.g., does not exceed the "warm" predetermined value) (step **684**), then the process **600** turns off the warm annunciator (e.g., a white LED) and the hot annunciator (e.g., a red LED), and turns on the cold annunciator (e.g., a blue LED) (step **688**). According to another embodiment, temperature may be caused to be shown on a display, etc. Process **600** then proceeds to determine if the faucet switch is ON or OFF (step **610**).

According to other embodiments, the process **600** may be configured to determine whether the thermistor reading is in a range of values, whether the thermistor reading is less than a predetermined value, whether the thermistor reading is above a predetermined value, or some combination thereof.

Returning to FIG. **32**A, if the faucet switch is OFF (step **610**), the process **600** closes the solenoid valve, stops the automatic shut off timer, turns off sensor power, and sets the faucet state to OFF (step **690**). For example, if the process **600** detects the handle **3** is in a closed position (e.g., via the switch **440**), then the electronic valve system turns off components, for among other things, to conserve power. Process **600** then proceeds to read the thermistor voltage using ADC (step **650**). Measuring and annunciating the fluid temperature even after the touchless or hands-free control system is turned off provides a user with temperature information. For example, if the previous user left the control handle **3** in the very hot position, the subsequent user may be forewarned of the temperature of the fluid. According to another embodiment, the thermistor may turn off after a period of time, after the fluid temperature has dropped below a predetermined value, or after the fluid temperature has progressed slowly downward through temperature ranges (cooled off). Accordingly, the thermistor may then be determined as absent at step **660**.

It is contemplated that other exemplary embodiments of the method may include more or fewer steps. For example, according to one embodiment, after closing the solenoid valve, stopping the automatic shut off timer, turning off the sensor power, and setting the faucet state to OFF (step **690**, see FIG. **32**A), the process may return to sensing if the faucet switch is ON or OFF (step **610**). Such an embodiment would bypass steps **650**-**688** when the faucet handle is detected closed. Similarly, after the solenoid valve is closed and the automatic shut off timer is stopped (step **642**, see FIG. **32**B), the process may return to sensing if the faucet switch is ON or OFF (step **610**). According to another embodiment, steps shown as a single step may be performed as separate steps. For example, closing the solenoid valve, stopping the automatic shut off timer, turning off the sensor power, and setting the faucet state to OFF (step **690**, see FIG. **32**A), may be performed as two or more separate steps or substeps.

Although the figures show a specific order of method steps, the order of the steps may differ from what is depicted. Also two or more steps may be performed concurrently or with partial concurrence. Such variation will depend on the software and hardware systems chosen and on designer choice. All such variations are within the scope of the disclosure. Likewise, software implementations could be accomplished with standard programming techniques with rule based logic and other logic to accomplish the various connection steps, processing steps, comparison steps, and decision steps.

Referring now to FIGS. **19**-**30**, the faucet **10** may further include a system for manually overriding the electronic valve system **5**. For example, in the event of a power failure, the electronic valve **100**, **200** may default to a closed position, and the faucet would be rendered inoperable until power is resumed. A manual override system allows a user to operate the faucet by manually actuating the electronic valve **100**, **200** from the closed position to an open position. According to the exemplary embodiments shown, the electronic valve **100**, **200** is a solenoid-operated valve, and a lifter is used to manually move the solenoid plunger from a close position to an open position. While a solenoid-based electronic valve is described with respect to the manual override system, it is contemplated that non-solenoid electronic valves may be used with the faucet **10**.

Referring now to FIGS. **19**-**22** and **26**-**27**, a first exemplary embodiment of the electronic valve **100** is provided. The electronic valve **100** includes a solenoid portion **110** and a valve body **120**. The solenoid portion **110** includes the components of any known, commercially available solenoid operated valve. For example, the solenoid portion **110** includes, but is not limited to, a sealing element **111**, a sealing surface **112**, a solenoid coil **113**, and a plunger **114**. The sealing element **111** may be, for example, a diaphragm, a poppet, etc. The sealing element **111** may include a pilot vent hole (not illustrated) and a second vent hole (not illustrated). Other components of the solenoid portion **110** that may be present in the electronic valve **100** may not be illustrated or may not be provided with reference numerals (e.g., a spring, gasket, etc.).

The valve body **120** includes an inlet **121** and an outlet **122** through which fluid is configured to flow through the electronic valve **100**. At one end of the valve body **120**, an interior of the valve body **120** includes threads **123** configured to receive and engage with a lifter **300**. An interior of the valve body **120** is substantially hollow in order to receive the lifter **300**. The valve body **120** may include a plurality of holes **131**, for example, two holes **131** configured to receive a pin **130**. The pin **130** is configured to limit the translation of a lifter **300**, thereby preventing the lifter **300** from being accidentally or unintentionally removed from the valve body **120** or from being over-tightened and damaging the solenoid portion **110**, **210**. Operation of the lifter **300** and the pin **130** will be discussed in further detail below. At the other end of the valve body **120**, the valve body **120** is configured to receive and engage with the solenoid portion **110**, such that some components of the solenoid portion **110** may be disposed within the valve body **120**, while other components of the solenoid portion **110** may protrude from the valve body **120**. Other components of the valve body **120** that may be present in the electronic valve **100** may not be illustrated or may not be provided with reference numerals (e.g., o-ring, screws, etc.).

Referring now to FIGS. **23-25**, a second exemplary embodiment of the electronic valve **200** is provided. The components and operation of the electronic valve **200** is substantially the same as the components and operation of the electronic valve **100**, except that the electronic valve **200** does not include the pin **130** and the plurality of holes **131** configured to receive the pin **130** in the valve body **120**. Instead, the electronic valve **200** includes a threaded cap **230** secured to a plurality of holes **231** disposed in the valve body **120** by a plurality of screws **232**. Similar to the pin **130**, the threaded cap **230** is configured limit the translation of the lifter **300**, thereby preventing the lifter **300** from being accidentally or unintentionally removed from the valve body **220**. Operation of the lifter **300** and the threaded cap **230** will be discussed in further detail below. Same or equivalent components as the first exemplary embodiment of the electronic valve **100** are given references numbers increased by 100 in FIGS. **23-25**, which illustrate the second exemplary embodiment of the electronic valve **200**.

Before describing the lifter **300** in detail, it should be noted that the lifter **300** of the electronic valve **100** (see, e.g., FIGS. **19-22**) and the lifter **300'** of the electronic valve **200** (see, e.g., FIGS. **23-25**) include similar elements (e.g., o-ring grooves **301**, **301'**, tips **310**, **310'**, handles **320**, **320'**, etc.). For clarity, the lifter **300'** and components thereof of the electronic valve **200** are indicated with a prime ('). However, for the purposes of this disclosure, lifter **300** may be used specifically to refer to the lifter **300** of the electronic valve **100**, or generically to refer to both of the lifter **300** of the electronic valve **100** and the lifter **300'** of the electronic valve **200**. One of skill in the art, upon reviewing the description and figures of this disclosure will recognize the similarities and differences of the lifter **300** and lifter **300'**, components thereof, and their interactions with the electronic valve **100** and electronic valve **200**, respectively. Accordingly, a lifter **300** may be used in conjunction with either or both the electronic valve **100** and the electronic valve **200**.

Referring now to FIGS. **19**, **20**, **26**, and **27**, an exemplary embodiment of the lifter **300** is provided. In the exemplary embodiment, the lifter **300** is a manually threaded device. In other embodiments, the lifter may be replaced, for example, with cams or mechanical linkages. Although the exemplary embodiment of the lifter **300** is manufactured in a single piece, in alternative embodiments the lifter **300** may be manufactured in a plurality of pieces coupled together by any known method, for example, by an adhesive, fasteners, etc. The lifter **300** is preferably formed of plastic. In other embodiments, the lifter **300** may be formed of any suitable material, for example, brass, stainless steel, or ceramic. The lifter **300** may be any color, such as a bright color to distinguish the lifter **300** from other components of the electronic valve **100**, **200** or the faucet **10**. Making the handle **320** of the lifter **300** a bright color or contrasting color to the rest of the electronic valve **100**, **200**, may draw a user's attention to the handle **320**, facilitating location and identification in low-light conditions (e.g., under a countertop, in a cabinet, or during a power outage). In addition, the lifter may be transparent, translucent or opaque.

The lifter **300** includes a first section **300**A configured to be received by and engaged with the valve body **120**, **220** and a second section **300**B configured to be exposed from the end of the valve body **120**, **220** that is not engaged with the solenoid portion **110**, **210**. The lifter **300** includes an o-ring groove **301** and threads **303**. The o-ring groove **301** is configured to receive and engage with an o-ring **134**, **234** (see FIGS. **19** and **23**) to seal the lifter **300** in the valve body **120**, **220** to prevent the electronic valve **100**, **200** from leaking. In one embodiment, threads **303** are configured to engage with threads **123** on the interior surface of the valve body **120**. In another embodiment, threads **303'** are configured to engage with threads **223** of the threaded cap **230**. The threaded cap **230** will be described in further detail below. In the electronic valve **100**, the first section **300**A is defined at one end by a tip **310** and at the other end by a recess **304**, adjacent to the threads **303** and configured to engage with the pin **130**. The second section **300**B of the lifter **300** is defined at one end by either the recess **304** or the threads **303**, respectively, and at the other end by a handle **320**.

The handle **320** of the second section **300**B of the lifter **300** is shaped to facilitate easy manual operation. In a preferred embodiment, the handle **320** is formed of two flat, parallel surfaces with a space in between the two surfaces. Thus, the user can manually operate the lifter **300** by placing two fingers, one on each surface, on the flat parallel surfaces of the handle **320** and rotating the lifter **300** in a desired direction. Alternatively, the user can manually operate the lifter **300** by placing a flat-head screwdriver or other flat, lever-type device within the space between the parallel surfaces and rotating the screwdriver or lever-type device in the desired direction.

Referring now to FIGS. **21** and **25-30**, the tip **310** of the first section **300**A is formed at an opposite end of the lifter **300** than the handle **320**. The tip **310** is configured to engage with the sealing element **111**, **211**. Operation of the tip **310** will be discussed in further detail below.

In an embodiment of the electronic valve **100**, when the lifter **300** is not in use (hereafter "normal operation"), the lifter **300** is inserted into the hollow portion of the valve body **120** and the threads **303** of the lifter **300** are threaded or partially threaded to the threads **123** of the valve body **120**. As used herein, "partially threaded" refers to a position in which some, but not all, of the threads **303** are engaged with the threads **123**. In other words, the lifter **300** may be further threaded to engage more of the threads between the lifter **300** and the valve body **120**. The pin **130** is inserted through the holes **131** disposed in the valve body **120**. The pin **130** rests within the recess **304** of the lifter **300**. The pin **130** interacts with surface ends (e.g., shoulders, ledges, etc.) defining the recess **304** to stop or limit translation of the lifter **300**. That is, the pin **130** prevents over-tightening of the lifter **300** and prevents unintentional removal of the lifter **300**.

Referring to the embodiment of FIG. **25**, during normal operation of the electronic valve **200**, the threaded cap **230** is placed over the lifter **300'** until the threaded cap **230** abuts an exterior of the valve body **220**. In this configuration, the threaded cap **230** and the lifter **300'** are coaxial. Holes disposed in the threaded cap **230** are aligned with the holes **231** disposed in the valve body **220** and secured by the screws **232**. The threads **303'** of the lifter **300'** are threaded or partially threaded to the threads **223** of the threaded cap **230**. The threaded cap **230** prevents unintentional removal of the lifter **300'**. A step **224** (e.g., shoulder, ledge, etc.) in the valve body **220** prevents over-tightening of the lifter **300'** and damage to the solenoid portion **210**.

During normal operation, the tip **310** does not engage with the sealing element **111**, **211** as the lifter **300** is not completely threaded, and thus, not completely inserted into the hollow portion of the valve body **120**, **220** (see FIGS. **28** and **29**).

In normal operation, the electronic valve **100**, **200** may be in the open position or the closed position. When the electronic valve **100**, **200** is in the closed position (see, e.g., FIG. **28**), the solenoid coil **113**, **213** does not produce a magnetic field. In this configuration, the pilot vent hole is blocked by the plunger **114**, **214**, causing inlet pressure to pass through the second vent hole and push the sealing element **111**, **211** onto the sealing surface **112**, **212**. In other words, the sealing element **111**, **211** abuts an entire length (e.g., an annular circumference) of the sealing surface **112**, **212** preventing the flow of fluid through the electronic valve **100**, **200**. Because fluid cannot flow from the inlet **121**, **221** of the valve body **120**, **220** to the outlet **122**, **222** of the valve body **120**, **220**, fluid is not provided to the faucet spout **1**.

When the electronic valve **100**, **200** is in the open position (see, e.g., FIG. **29**), the solenoid coil **113**, **213** produces a magnetic field that draws the plunger **114**, **214** towards the solenoid coil **113**, **213**. When plunger **114**, **214** moves towards the solenoid coil **113**, **213**, the plunger **114**, **214** opens the pilot vent hole in the sealing element **111**, **211**. In this configuration, pressure that was holding the sealing element **111**, **211** onto the sealing surface **112**, **212** is reduced, allowing inlet pressure to push the sealing element **111**, **211** off of the sealing surface **112**, **212**. As a result, the sealing element **111**, **211** no longer abuts an entire length of the sealing surface **112**, **212** and fluid may flow between the sealing element **111**, **211** and the sealing surface **112**, **212**. Because fluid can flow from the inlet **121**, **221** of the valve body **120**, **220** to the outlet **122**, **222** of the valve body **120**, **220** fluid is provided to the faucet spout **1** if the handle **3** is in the operational mode.

If the electronic valve **100**, **200** is in the open position and the handle **3** is in operational mode, fluid can flow through the valve body **120**, **220** from the inlet **121**, **221** to the outlet **122**, **222** despite the lifter **300** being inserted into the valve body. This is because in an exemplary embodiment, the lifter **300** has a cross-shaped cross-section defined by a plurality of passages **302** that extend along a length of the lifter **300** in at least the first section **300A** (see FIGS. **21** and **26**). In other embodiments, the lifter **300** may have other shaped cross-sections, provided that the lifter **300** contains one or more passages that allow for fluid flow.

In the event that power failure renders the electronic valve **100**, **200** inoperable, the lifter **300** may be rotated clockwise to place the lifter **300** in "override operation". As the lifter **300** is rotated clockwise, the threads **303** advance the lifter **300** into the valve body **120**, **220**. During override operation (see, e.g., FIG. **30**), the lifter **300** is fully inserted/threaded into the valve body **120**, **220** such that the tip **310** engages with the sealing element **111**, **211** and pushes the sealing element **111**, **211**. When the sealing element **111**, **211** is pushed, the sealing element **111**, **211** is lifted from the sealing surface **112**, **212** and fluid may flow from the inlet **121**, **221** to the outlet **122**, **222** of the valve body **120**, **220** through passages **302** of the lifter **300**. When power is restored, the lifter **300** may be rotated counterclockwise to disengage the tip **310** from the sealing element **111**, **211** and place the lifter **300** in normal operation.

Although the description of the embodiments provided herein utilizes the lifter in the context of a solenoid operated valve located in a faucet, one of ordinary skill in the art would understand that the lifter may be utilized to manually override a solenoid operated valve located in any other device. Therefore, operation of the lifter is not limited to use in faucets.

As utilized herein, the terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numerical ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and claimed are considered to be within the scope of the invention as recited in the appended claims.

The terms "coupled," "connected," and the like as used herein mean the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another.

References herein to the positions of elements (e.g., "top," "bottom," "above," "below," etc.) are merely used to describe the orientation of various elements in the FIGURES. It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

It is important to note that the construction and arrangement of the faucets, sensors and sensor holders as shown and/or described in the various exemplary embodiments is illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described herein. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the present invention.

What is claimed is:

1. A system for manually overriding a solenoid operated valve in an event of power failure, comprising:

a solenoid operated valve, the solenoid operated valve comprising:

a valve body including a sealing surface, a fluid inlet and a fluid outlet;

a sealing element selectively separating the fluid inlet from the fluid outlet;

a solenoid configured to selectively couple and decouple the sealing element to the sealing surface;

a lifter threadedly coupled to the solenoid operated valve; and

a pin inserted into a plurality of holes disposed within the valve body such that the pin rests in a recess of the lifter, wherein the pin limits translation of the lifter, and wherein rotation of the lifter relative to the valve body in a first direction causes the lifter to decouple the sealing element from the sealing surface.

2. The system of claim **1**, wherein the lifter and the valve body are coaxial about a single shared axis, and the lifter is rotated about the single shared axis.

3. The system of claim **1**, wherein rotation of the lifter relative to the valve body in a second direction causes the lifter to retract such that the sealing element and the sealing surface are recoupled if the solenoid is not energized.

4. The system of claim **1**, further comprising a threaded cap, the threaded cap abutting an exterior surface of the valve body and being secured by a plurality of screws, wherein the threaded cap limits translation of the lifter.

5. The system of claim **4**, wherein the lifter is threadedly coupled to the threaded cap.

6. The system of claim **1**, wherein the lifter is threadedly coupled to the valve body of the solenoid operated valve via threads, and wherein during the power failure, rotation of the lifter in a second, opposing direction moves the lifter via the threads relative to the valve body to couple the sealing element to the sealing surface.

7. The system of claim **1**, wherein the lifter comprises a tip formed at one end of the lifter and a handle formed at an other end of the lifter, wherein the tip is configured to engage with the sealing element, and wherein the handle is configured to facilitate manual actuation of the lifter.

8. The system of claim **1**, wherein the lifter includes a first section, which is configured to be received by and engaged with the valve body, having threads disposed thereon and the threads threadedly couple the lifter to the valve body.

9. The system of claim **8**, wherein the lifter includes a second section, which is configured to be exposed from the valve body, such that the second section is rotatable from outside of the valve body.

10. A method of providing a solenoid operated valve with manual override capability in an event of power failure, the solenoid operated valve including a solenoid configured to selectively couple and decouple a sealing element to a sealing surface, the method comprising:

providing a valve body comprising the sealing surface, a fluid inlet and a fluid outlet, the fluid inlet and the fluid outlet selectively separated by the sealing element;

providing a lifter configured to be inserted into the valve body, the lifter being capable of rotating relative to the valve body in a first direction such that the lifter is threadedly coupled to the solenoid operated valve via threads disposed on a first portion of the lifter, and the lifter also being capable of advancing into the valve body by the threads of the lifter, such that the lifter engages with the sealing element, causing the sealing element to decouple from the sealing surface; and

inserting a pin configured to secure a position of the lifter and prevent a user from over-threading the lifter into a hole disposed within the valve body such that the pin rests in a recess of the lifter, wherein the pin limits translation of the lifter.

11. The method of claim **10**, further comprising rotating the lifter relative to the valve body in a second direction such that the lifter retracts and disengages from the sealing element, causing the sealing element to recouple to the sealing surface.

12. The method of claim **10**, wherein rotating the lifter comprises a user manually turning the lifter by the user's hand.

13. The method of claim **10**, wherein rotating the lifter comprises a user manually turning the lifter by a lever-type device.

14. The method of claim **10**, wherein the pin interacts with surface ends defining the recess to limit translation of the lifter.

15. The method of claim **10**, wherein the lifter includes a second portion, which is configured to be exposed from the valve body, such that the second portion is rotatable from outside of the valve body.

16. The method of claim **10**, wherein the lifter and the valve body are coaxial about a single shared axis, and the lifter is rotated about the single shared axis.

17. The method of claim **10**, the lifter comprises a tip formed at one end of the lifter and a handle formed at an other end of the lifter, wherein the tip is configured to engage with the sealing element, and wherein the handle is configured to facilitate manual actuation of the lifter.

* * * * *